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Issues and Opinions

Information Technologies in Business: A Blueprint for Education and Research

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How are business schools thinking about developing leaders for the emerging digital economy? Is there a set of core principles we can apply to thinking about the enabling potential of information technologies and their consequences for business and society? We present a business-centric framework and a technology-centric framework that together form a blueprint for answering these questions. The business-centric framework articulates three compelling reasons why information technology (IT) matters in business: (1) IT continually transform industry and society, (2) executive decisions about IT investments, governance, and strategy are critical to organizational success, and (3) deriving value from increasingly available data trails defines effective decision making in the digital economy. However, our conversations with the leadership of 45 business schools and our subsequent data indicate that business schools are challenged by effectively training future executives to think about these reasons and act on them as part of a forward-looking program of business education that is grounded in stable concepts. In response, the technology-centric framework provides a set of grounding concepts and stable principles about IT that have emerged over the last four decades, and leads to a natural set of consequences that can inform thinking about IT in business. We illustrate how these complementary frameworks—business and technology—can be combined to frame an educational program by outlining a set of key questions, by placing these questions in the context suggested by our frameworks, and by providing guidelines toward answering them. These questions also define a natural path for future research about IT in business and society that will lead to stronger intellectual foundations for the field and define future education that is better grounded in concepts and theories that emerge from academic research.

Key words: IT strategy; corporate strategy; IT investment; education; electronic commerce; business transformation; disruptive technology; platform; business value; decision making; digital goods; network economics; social networks; MBA core

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1. Introduction

How should business schools educate managers for a global economy in which information technologies are increasingly central? There is a great deal of interest among the leading business schools in answering this question as part of a program that is simultaneously forward looking and grounded in stable concepts. Based on a multiyear series of interviews with business school deans and numerous panel discussions at academic conferences, our research provides a blueprint for a core set of concepts, frameworks, and questions that every future executive must understand and answer to think creatively and effectively about information technologies and their consequences for business and society.

The motivation for this study is simple. In today's business world, information technologies are central to the development and delivery of a number of products and services, and are often core to the product itself. They mediate an increasing fraction of the interactions among consumers, within firms, between firms and their customers, and allow participants to continually and fluidly influence the design of the synthesized spaces in which the interactions

occurs. They increase the volume and accuracy of data generated by such interaction, the ability of firms to analyze these data, and their capability to respond creatively to signals from markets and customers.

As a consequence of the centrality of IT in commerce and society, business models in industries that were stable over many decades face persistent challenges for the foreseeable future. Success is governed increasingly by a firm's ability to respond to and influence the transformation induced by IT, rather than merely by the firm's operational or organizational excellence within the secure confines of a stable business model. Consider, for instance, those companies profiled in the best-selling business book *Built To Last*, each of which outperformed the market in four successive decades, from the early 1950s to the early 1990s. Of these 18 companies, 12 have performed worse than the market over the last decade (Hamel 2003). However, this is not surprising when we recognize that the industries in which many of them operate—financial services (Citigroup, American Express), corporate computing (IBM, HP), mobile handsets (Motorola), consumer electronics and music (Sony), entertainment (Walt Disney), and retailing (WalMart, Nordstrom)—are among those that IT has transformed radically over this decade.

IT is not just transformational. It is also a central determinant of the successful business models and industry structure of a growing fraction of the economy. It has become a major driver of productivity growth, and there is evidence of significant variance in the performance of companies based on how effectively they use IT (Brynjolfsson and Hitt 2000). As IT becomes cheaper and more ubiquitous, the opportunities for co-invention and devising organizational complements that realize the value of technological inventions grow steadily. There is frequent trade press speculation about how a new IT like RFID, wireless broadband, or biometrics, or a new IT-enabled business or business model might transform an industry, or change the way we communicate, market, govern, and entertain. Expanding connectivity, mobility, and digital convergence will only accelerate this trend. At the same time, managers are increasingly concerned about their inability to make technology decisions rationally because of the complexity and far-reaching business consequences of such decisions, and also because of the need to invent business models and organizational strategies that take advantage of the growing centrality of IT in business.

How are business schools thinking about developing leaders for this type of emerging digital economy? How should business schools be training students to assess the threats to business models, and capitalize on opportunities enabled by emerging information technologies? Are there some general principles that can be applied to answer these questions?

We think there are. In this article, we propose a structure for educating future business executives about information technologies. We present three central reasons that frame the importance of IT in business. We provide a set of technological invariants and the consequences that we conjecture will lead to stronger conceptual foundations for this education. We contextualize these frameworks using a set of questions that frame a program of education about IT in business. We summarize what is known about the answers, and we highlight the natural areas for future research that might contribute further.

2. IT in Business: Background and Current Thinking

A schoolwide inquiry into core MBA education was initiated at New York University's Stern School of Business in 2003, reflecting the school's philosophy that a business course should be organized around a central question. The basis for this philosophy is that once this central question is defined, it provides coherence and stability to education, because it keeps intellectual content relatively stable while admitting examples and cases that vary with business context or the special interests and competencies of the students and faculty.[1]

The inquiry at Stern served as a catalyst for broader thinking about IT in business education. Our initial program of inquiry culminated in our convening a

[1] Consider, for example, what the core questions might be in finance and marketing. In finance, it might be "How do you price assets and assess their risk?" As new assets emerge, new methods for pricing them are defined, but the question remains immutable. The marketing core question could be "How do you best acquire and retain customers?" Again, cases change as channels and consumer behaviors evolve, but the question stays the same.

panel at the December 2004 International Conference on Information Systems (ICIS), the flagship conference in IS, to initiate a discussion in the IS community about questions fundamental to IT in business education. During the summer of 2005, we interviewed 45 business school deans about their views on the importance of IT in business and how it should be integrated into a business curriculum. The typical duration of these interviews was 30 to 45 minutes (although many lasted well over an hour). Thirty-five deans participated personally,[2] six delegated participation to an associate dean, and four delegated it to professors whose responses they maintained reflected the dean's position. Details about the interviews are provided in Dhar and Sundararajan (2006). We discussed these findings on the plenary panel at the 2005 Workshop on Information Systems and Economics, at a Harvard Business School (HBS) teaching workshop about IT in business in May 2006, and on a plenary panel of the First International Symposium on IS. We convened another panel at ICIS in December 2006 to add a richer perspective from deans, business school professors, and influential IT business writers. We have had numerous conversations with our academic peers. Each of these data sources has informed the analysis that follows.

The current thinking about IT in business education can be summarized by the perspective provided by the deans. Out of 45, 43 were affirmative in their answer to the question "Do you think that teaching MBA students about IT in business is necessary?" We discussed, at some length, the basis for their position, which is summarized in the following three points.

(1) Information technologies continually *transform business and society*. They are a central driver of accelerated globalization. They cause major changes in the structure of industries and shape successful business models within them. A large fraction of future wealth creation will be due to progress in technology (and especially information technologies). Successful executives in the future will have a clear understanding of *how to think about the transformative and wealth-generating potential of information technologies*. Roughly half the deans indicated this transformational perspective as their basis for education about IT in business.

[2] Two of these 35 deans responded via e-mail.

(2) *Investments in IT are critical* to the success of organizations. Successful managers will be able to assess and invest in the IT that best supports their business model. They will institute governance practices that lead to the appropriate level of investment in these technologies. They will know how to appropriately manage and measure the return on these investments. They will be equipped to identify the right inputs into models that form the basis for such analysis. About a quarter of the respondents fell into this category.

(3) *Innovation and creativity in the use and application of data for decision making* is critical to success as a business executive. A growing fraction of these data are generated and available as a by-product of electronic commerce. IT defines the data blueprint of an organization. Data are key to knowledgeable and effective decision making. Organizations that base and evaluate their decision making on hard data will have an advantage over those whose data are unavailable to decision makers. Roughly a quarter of the deans shared this decision making-oriented view of IT.

3. IT in Business: Conceptual Foundations

Business schools continually struggle to find the right balance between conceptual rigor and relevance to current and future practice. This problem becomes particularly acute for emerging areas where a combination of engineering breakthroughs and empirical phenomena involving the interaction of human behavior and information technologies drive the development, over time, of frameworks and theories.

The problem of how to integrate IT in the business curriculum has always been tricky, although it was not particularly important as long as IT could easily be relegated to the back office, managed by specialists. However, as the economy continues to become more information oriented and business models become increasingly IT based, business executives are forced to understand the transformational impacts of technologies and to make IT investment and management decisions that have more far-reaching consequences for the success of their enterprises.

The IT problem thus cannot be ignored any longer by a forward-looking business school. The dean of the

Stern School of Business at New York University, Tom Cooley, describes the goal of a business school as

> Providing a meaningful and serious intellectual experience, one that prepares students to be leaders in a complex evolving world... the mission is to understand markets, firms, and prices as well as to develop new strategies and discourses for understanding how they work, how they interact, how they impact society. (Cooley 2005)

One of Cooley's points is that when preparing students for a career that will span multiple decades, general theories will have more enduring value than facts and context that describe the current business environment. Richard Schmalensee from MIT's Sloan School and Edward Snyder from the University of Chicago echo a similar sentiment, highlighting a belief in teaching concepts that remain stable within an evolving business context. Examples of such concepts include those embodied in the economics of markets, statistical analysis, human decision making, and problem solving. At the same time, however, Cooley, Schmalensee, and Paul Danos of the Tuck School at Dartmouth speak about the importance of being forward looking. Considering the extent to which information technologies will be a part of the wealth creation process going forward, they say it is important that students understand how to *think* about these technologies and their consequences.

As we have documented (Dhar and Sundararajan 2006), there is considerable diversity in the extent to which IT is represented in business education and how it is delivered. Diversity is not uncommon in the early stages of education about an emerging area.[3] Howard Frank, dean of the University of Maryland's Robert H. Smith School of Business, notes that the lack of theory should not be viewed as an excuse not to cover areas where theories are still emerging, but which are clearly important for future business leaders. In one of our recent discussions he noted that "It is not clear to me that any emerging transformational area can have much theory behind it in the beginning. In fact, this is precisely the time that an innovative program should begin to incorporate it into the curriculum."

Taken to its extreme, Frank's point might imply that business schools that are too conservative in this respect might be looking for the keys under the proverbial lamppost just because the light is there while ignoring more critical educational imperatives as they wait for the light to emerge. For example, the models of inventory management that are a staple in most core MBA operations courses have not changed over the last decades. The former dean of the Wharton School, Patrick Harker, notes that over the same period, however, the fraction of the gross domestic product (GDP) generated by the service economy has increased dramatically, and the important operations problems most U.S. executives need to be familiar with have more to do with managing services rather than with the procurement or assembly of physical goods.

Although Frank's broader point is well taken, we argue that IT in business does in fact have a stable conceptual grounding. Our position is that we have had sufficient evidence over the last four decades to identify certain principles that enable us to interpret the past and make reasonable predictions about current and future issues facing business executives relating to information technologies. We refer to these principles as *invariants* because we expect them to hold for the foreseeable future and to serve as foundations for thinking about IT in business and society. We do not mean to imply that these invariants are exhaustive. However, they provide a sufficiently solid conceptual basis for us to outline the issues and questions business schools should be thinking about to strengthen their education.

What are these invariants? If we consider the history of IT in business in the last 40 years, three emerge indisputably.

The first technological invariant is the rendering of things as information, and in particular, as digitally represented information. A bank balance is information about wealth (occasionally rendered into

[3] Organization theory in the 1960s was described by Herbert Simon as consisting of "proverbs of administration" often with conflicting advice such as "look before you leap" and "he who hesitates is lost." Over time, more sophisticated theories of organization emerged. Empirical computer science, defined by Newell and Simon (1976) as "the study of the phenomena surrounding computers" has similarly come a long way in the last three decades as our understanding of human problem solving, machine learning, and related areas has grown to the point where there is sufficient conceptual material to offer degree programs in these areas.

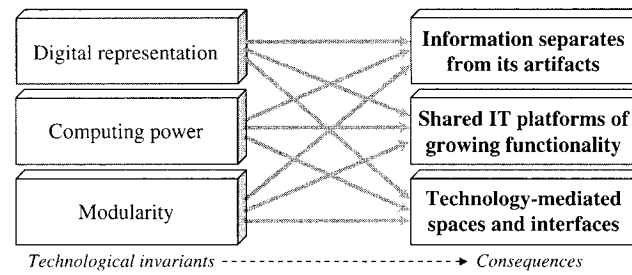
physical money). Music, voice, and video are information about frequency, pitch, and color, and the rate at which these change. A trading strategy is a set of rules and algorithms (code) that act on information. A commercial drug is information rendered into chemicals in a capsule. Each of these kinds of information can be digitized. Once digitized, this information is amenable to a variety of forms of computation and transport.

The second invariant is the sustained exponential growth of hardware power, bandwidth, storage, and the accompanying miniaturization of IT-based devices. Moore's law is an empirical rendition of this phenomenon. As the power of IT crosses various thresholds, the capabilities it enables causes disruptive shifts in markets and society. Massive parallelization and the move of functionality and reliability to software (epitomized by Google's current approach to radically more effective large-scale computing using mass-market hardware) are accelerating this trend.

The final invariant is the most subtle and provides real power to the first two. It is the sustained increase in programmability, in a modular way, whereby increased complexity can be aggregated, codified, and eventually integrated into standardized software platforms. It allows capability to be added to existing IT-based general purpose devices merely by the addition of software, or a set of digital instructions. It allows other software to call on and use this capability. Modularity is fundamental to the increasingly powerful transformative effect of IT on business and society. The addition and improvement of modular layers can enable capabilities and business models that would not exist otherwise. Modular programmability allows devices to cross thresholds that make them suitable for purposes that were previously not feasible or practical.

Programmability is not a new idea. In the 1960s, Herbert Simon characterized decision making on a continuum of programmability, predicting that computers would replace programmable organizational functions, leaving humans to handle the nonprogrammable tasks, especially those involving interpersonal communication and judgment. Although aggressive, Simon's predictions have materialized, with information-processing infrastructures of increasing complexity becoming programmed and available as

Figure 1 A Technology-Centric View of IT in Business



modules that handle entire processes from order taking to fulfillment, inventory, and customer support, functions that previously required more active intervention by human beings.

Why are these three invariants relevant to business? They are relevant because when combined they lead to at least three consequences of future importance, as summarized in Figure 1. There may be other consequences of this kind that are derived in the future, and the technological invariants provide a basis for identifying them. There clearly is a process of innovation by individuals, firms, and decentralized groups of individuals acting collectively, that connects the invariants to these consequences. Although we acknowledge the importance of such innovation, we do not describe it in this paper. Instead, we focus on the outcomes—the major consequences of the technological invariants that seem to recur, rather than the process of technological innovation that causes each to emerge.

What are these consequences? First, digital representation in conjunction with the growth in processing and communications power facilitates the *separation of information from a growing number of artifacts*. Digitization makes this separation *feasible*, the exponential growth in the power of hardware and network bandwidth makes it *practical*, and modularity makes the associated rendering of the information possible via software running on a *general-purpose device*. For example, the capability to digitize music existed for a long time before the commercial digitization of music, which occurred only when there was a high-capacity storage medium inexpensive enough to hold the hundreds of megabits that comprise a three-minute song, and a special-purpose mass-market hardware device, the CD player, powerful enough to render these millions of bits in real time. Even so, music remained tied to a tangible artifact,

the CD, which required a special-purpose device to render its information. The separation of the digital information contained in a song from this artifact became *useful* only when there was sufficient bandwidth to easily send and receive these millions of bits, and when enough consumers owned sufficiently powerful general-purpose computers that could run the software capable of such rendering. The digitization of voice telephony and video has occurred for long-haul transmission and the separation of digital video from its artifact, the DVD, is imminent as user-generated video sites like YouTube gain popularity and innovative delivery technologies (like the peer-to-peer streaming video of Joost in 2007) gain mainstream adoption. Most money has been separated from its operational artifact, the bank note.

The separation of information from its artifacts alters the fundamental economics of a number of industries. Their products become information goods, often subject to network economics, and whose channels are software based. Music, film, and publishing are early examples; there will be more. Recall that music was not considered a part of the IT industry 20 years ago.

Second, IT infrastructures become progressively larger, more powerful, and more accessible. They become more powerful because hardware is faster, software can be layered in a modular fashion, and their combined capability becomes more accessible as network bandwidth continues to grow. This trend has characterized the IT industry over the last 50 years, from the emergence of standard commercial computers in the 1950s and 1960s, the creation of the first standardized platform, the IBM System/360, through the recent availability of billion-dollar, off-the-shelf enterprise resource planning and supply chain management software platforms, and to the on-demand retailing and search platforms of Amazon.com and Google.

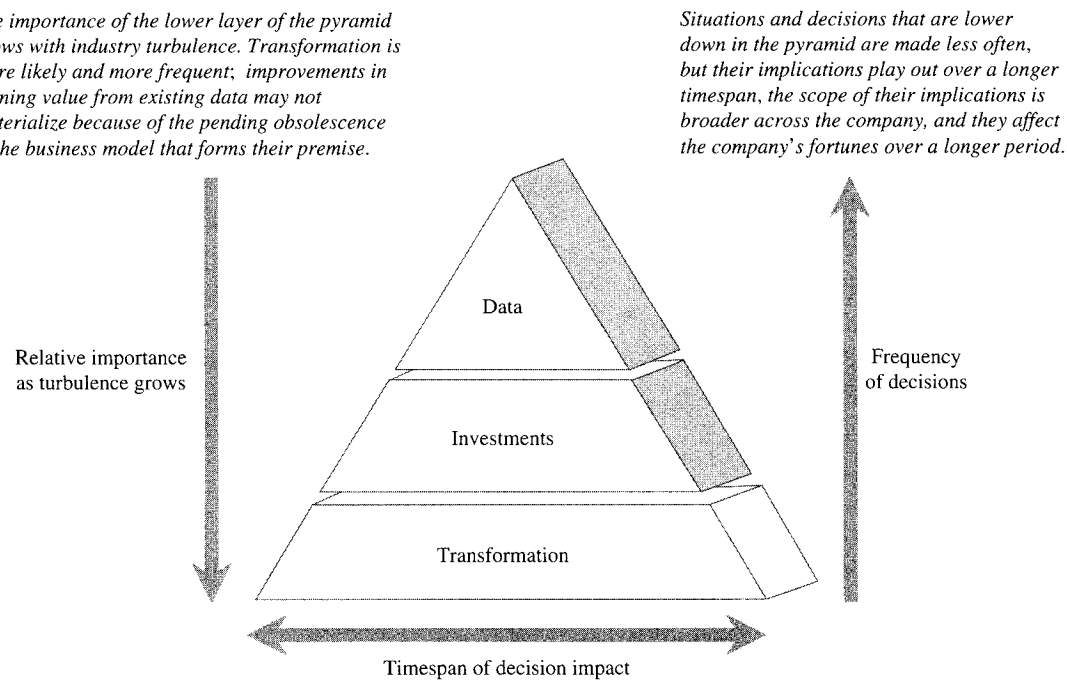
The emergence of these infrastructures can cause the capability to *develop and manage* generic complex IT infrastructures of commercial value to diminish in importance over time (Carr 2003), but this has always been the case. Each of the developments that "commoditizes" some aspect of IT and reduces the return on being able to develop this IT is also accompanied by an *increase* in the relevance and impact of IT on business.[4] As noted by Vijay Gurbaxani, this leads to an increase in total business spending on IT (Gurbaxani 2003), and often, a dramatic shift in the business models and structure of industries that were once not considered part of the IT industry. The interpretation of the recent visibility of powerful and shared infrastructures as evidence of the commoditization and shrinking importance of IT to business professionals misses a deeper point, namely, that the larger shared infrastructures create significant *opportunities* and *threats* for companies, which must be explicitly addressed when framing corporate strategy. Capabilities to build IT infrastructures always get commoditized over time. What is important is what these large shared infrastructures enable, and the extent of change they engender.

The "platformization" of capabilities need not be radical, but can be incremental. For example, the ability to represent audio digitally combined with the increasing power of hardware and its capability to run increasingly sophisticated algorithms leads to a steady improvement in digital speech recognition over time. Early innovators may indeed benefit from developing, commercializing, and using such technology. However, our framework suggests that this functionality will be integrated into a platform of some sort (perhaps an operating system) over time. The integration is possible because of the modularity of software, and is commercially viable because the hardware running the platform eventually becomes sufficiently powerful.

The third major consequence of the three invariants is a growth in society of the importance and variety of "spaces of interaction" that are mediated

[4] More specifically, the emergence of commercially available computers in the 1950s and 1960s increased their use in business and research (although reducing the value of being able to build one). The availability of the IBM System/360 with a standardized operating system facilitated this further (but reduced the value of being able to develop and deploy specialized business applications). The availability of off-the-shelf enterprise resource planning and supply chain management software lets more firms use them to manage their operations (although managing the building of customized firmwide information systems becomes a less critical capability for modern managers). A potential online vendor can now simply "plug into" Amazon.com's retailing platform in exchange for a per-transaction fee rather than needing to build electronic shopping systems from scratch.

Figure 2 A Business-centric View of IT in Business



by IT. The fundamental difference between these synthesized spaces that foster computer-mediated communication and the "built spaces" (Lessig 2000) that govern behavior in the physical world is that the former are shaped continuously and fluidly by the participants who occupy them. More powerful infrastructure allows participants to support the complex interfaces of these spaces. Software modularity enables these spaces to evolve and lets participants build new ones with little effort. Progress in hardware facilitates mobility in the device that renders this space. The digital representation of everything facilitates exchange mediated by these spaces: Devices can organize and manipulate information in a way not previously possible, giving rise to new social structures and business models, and disrupting existing ones. Contrast this with the pace of change in telephonic or face-to-face communication that analog networks or physically built spaces mediate.

The three consequences of these invariants describe a *technology-centric* view of thinking about IT and its consequences for business and society. In the rest of this section, we elaborate on an alternative *business-centric* view of IT that is based on the three reasons identified in §2 explaining why IT matters in business. Bringing together the technology- and business-centric views leads to a natural set of general questions about information technologies in business. We describe these questions in §4 and elaborate on how these complementary views can define and frame education and future research.

Figure 2 illustrates a business-centric view that encapsulates the three reasons why IT matters in business. This pyramid provides a classification that can situate and contextualize any decision that relates to IT in business. The industry and business *transformations* enabled by IT, depicted in the lowest layer of the pyramid, occur relatively infrequently in any industry. The scope of the related situations and decisions is broad, however, often requiring a radical rethinking of a firm's business model and strategy. Executives therefore need to be vigilant about how information technologies might be transforming their industries and must be able to anticipate future transformation before it occurs. We illustrate this with examples in the following section.

The IT *investments* and related strategic choices that form the next layer are made in the context of the successful business models established by the transformation that has occurred at the base. Typical decisions

involve optimizing spending on information technologies by aligning these investments with the firm's business strategy, the design and implementation of the processes that employ the technologies, and by instituting the appropriate IT governance structures. While these investment decisions tend to have multi-year impacts, especially those pertaining to platforms and infrastructure, payoffs typically depend on execution and management review on a more frequent basis.

At the top of the IT pyramid are problems relating to the generation, effective use, and governance of a firm's *data*. A larger volume of data is generated each year as commerce becomes increasingly electronic and technology-mediated spaces grow in their scope and importance. The situations that executives will face more frequently in the future relate to generating the right data and making sure that the organization has sufficient "information liquidity."[5] It also requires making data governance choices that trade off the value of data as an asset with the potential liability that its inappropriate use might impose. Success with data depends directly on the firm's IT infrastructure, and thus on the firm's IT investments and strategy. Further, the value, stability, and appropriate use of data depend on the nature and stability of the business models defined by any prior transformation in the industry. It is possible, however, that innovative investments by individual companies at the higher layers of the pyramid will lead to capabilities that are responsible for future industry transformation.

The relative importance of each layer will vary across industries and across time. In industries that are more turbulent (or which have a higher clock-speed in the terminology of Mendelson and Pillai 1998), executives are more likely to focus attention on the implications of IT-related transformation, because understanding impending shifts in business models can be central to a firm's survival. Efforts towards gaining value from data or in choosing the right IT investments may not pay off if the business model of a firm is likely to change in the near future. This is because IT investments that are not aligned with a firm's strategy often fail, and a firm's strategy in turn depends on the business models that will be successful for its industry. On the other hand, in more stable industries, the IT investment and data layers gain more importance. Indeed, evidence suggests that when market sizes can be reliably estimated managers make bold capital decisions that often pay off (Christiansen 1997). They can also define exactly what data are needed to make good decisions, and invest heavily in generating this data, sometimes by making the decisions necessary to facilitate its creation. After all, decisions lead to data, which lead to decisions. Industry stability makes it more likely that these investments will pay off.[6]

4. IT in Business: Bridging Education and Research

To provide context to the bidirectional framework we have laid out in §3, we ask what fundamental questions these technology-centric and business-centric views suggest? The answers to these questions and the questions themselves frame what future executives need to be educated about. The questions also define a path for research about IT in business that is most likely to link research to education in a manner that strengthens its intellectual foundations. Education about a successful business discipline is typically informed by the research conducted by its academics. The core body of knowledge that is imparted to students should have its foundations in the primary (current or past) programs of research that engage the scholars of the field. The uniformity and conceptual

[5] We refer to information liquidity as the ability of an organization to transform its data assets into information that can be used for decision making. The concept is more fully explained in Dhar and Sundararajan (2000).

[6] The financial services industry is a good example of a low-turbulence, but highly information-intensive industry, where business models are relatively stable and well defined, and firms look to squeeze value from scale, advantages in risk management systems, proprietary algorithms, and better customer service. For financial companies, it makes sense to invest in creating information assets because the business model is stable and payoffs can be quantified. In contrast, media and communication companies are in a highly turbulent environment where information technologies are playing a key role in redefining business models, and where markets and industry boundaries are being redefined. Defining the data that are useful and putting structures in place for their generation and governance seems like a less compelling focus when the business models the data inform are subject to imminent change.

strength of education about IT in business will therefore be accelerated if academic research addresses those questions that are central to the field and most effectively inform its desired educational content.

Before presenting our questions, two points are worth noting. First, we do not intend to articulate a comprehensive set of questions, although we have aimed to be fairly exhaustive. We present a set that can currently frame a program of education about IT in business, and which also represents important immediate directions for academic inquiry that are likely to have lasting value. Second, we summarize some of what is known about how to answer these questions largely in the context of prior theory and current business cases that illustrate their importance, while briefly summarizing what further research and thinking might add to what is known. The former is meant to suggest how these questions might be addressed in a classroom setting, and the latter aims to influence future academic inquiry. This integrative approach is most likely to fulfill our goal of future education about IT in business that has stronger research-based conceptual foundations.

4.1. Business-centric Questions

The first set of questions flows from the business-centric framework of IT in business. These relate directly to issues of immediate importance to businesses. The questions themselves can be used to define a program of education (a course, for instance, or a module of an executive education sequence) about IT in business.

4.1.1. How Does IT Transform Industries and Change the Boundaries Between Them? IT-driven industry transformation is often a result of combining two consequences of the technological invariants, the separation of information from its artifacts and the emergence of powerful shared infrastructures like the Internet or OS-based general-purpose hardware. This combination shifts the capabilities and functionality that mediate channels and consumption interfaces into software that is eventually installable on general-purpose devices of increasing power. As a result, physical network ownership or channel access becomes less of a basis for sustainable competitive advantage, replaced instead by ownership of the standard for the rendering interface, and sometimes an algorithm for the effective transport of information over a shared general-purpose network. The erosion of profits for the owners of the microwave radio relay networks in long-distance telephony is an early illustration of this phenomenon.[7] If we apply the technology-centric framework to analyze changes in the competitive forces that determine industry structure (Porter 1979) in this context of long-distance wireline voice, we get a useful historical illustration of transformation that could have been predicted well in advance of its occurence. A similar blending of the technology-centric framework and Porter's model can be applied to analyze how the emergence of high-speed general-purpose wireless data transport threatens incumbent cellular service providers whose ability to provide a service—mobile voice communication—relies on the ownership of proprietary (and special-purpose) wireless networks. We have found that this is a fascinating current classroom discussion topic across undergraduates, MBAs, and executives, because it predicts transformation that is yet to occur, and leads to a realization of how the first two technological invariants constantly blur boundaries between previously disparate industries, like cable TV and wireline telephony, or mobile computing and cellular handsets. Choosing appropriate shorter-term strategies for incumbents—whether to cannibalize existing business by building new infrastructures versus deterring entry—provides a complementary debate. Future research can inform this debate through empirical work linking such transformation to the evolution of industry profits over time,

[7] More specifically, the AT&T "Long Lines" circuit-switched network carried a vast majority of the long-distance voice and long-haul television traffic from the 1940s to the 1980s. Ownership of this relatively "special purpose" network was the basis for AT&T's high profit margins from their long-distance business. In the mid 1980s, AT&T resisted the move to networks based on the packet-switching technology that forms the basis for today's Internet. This architecture also makes the network content and user agnostic. That is, the Internet carries data with little awareness of whether the data represents voice, video, text, images, or music, and from any device with a valid IP address to any other. The "intelligence" of the network is at its edges, the computers connected to the Internet that use it for data transport. As a consequence, ownership of a network is no longer necessary to provide a product or service that requires access to infrastructure for widespread digital information transmission or exchange.

and through theory that defines the scope and sustainability of IT-enabled transformation of this kind.

A second way in which IT is fundamentally transformative is that it can replicate and often vastly improve on, in an automated and scalable way, the *matching* that forms the basis for many industries. As a consequence, firms that provide intermediation face a constant threat of potential transformation that is caused by IT. We have witnessed this already in secondary financial markets (brokerage, exchanges). The transformation of advertising that is underway because of Google and Yahoo is a more current example. More specifically, the emergence of Google's shared search infrastructure has led to an increase in the *precision of intent* expressed by consumers that can be captured by firms, and the *timeliness* with which this intent can be responded to. Applying the technology-centric framework suggests that as these infrastructures become more powerful, they will capture intent with greater precision. As portable devices become more powerful and enable new spaces of interaction, the number of points of contact at which this intent is captured will grow. The mobility of these devices will allow the scope of situations in which precise and timely responses can be provided by sellers to expand considerably. As these IT-mediated spaces of interaction become more popular and powerful, the scope of intent expressed will become richer—not just a few keywords, but perhaps also including richer visual and auditory cues. This might suggest a future for the advertising industry that is almost exclusively intent driven and based on narrowcasting instead of broadcasting. Viewed in another way, although narrowcasting is not yet widely viable because most consumer intent cannot be reliably inferred or responded to today, it will become increasingly widespread as the capabilities of technology to capture intent grow over time.

Future industries that may be candidates for transformation that is driven by matching being subsumed by an IT-based system include media intermediation as well as brokerage of other forms (real estate and insurance, for example). The often-discussed example of primary financial markets, the richest intermediation industry, is more complex. Although Google's Internet-based IPO was a mixed success, it was conducted within an industry structure where channel access to the large institutional investors was controlled by incumbent firms. If a significant fraction of revenues for a bank are derived from proprietary trading based on pools of information gained from their primary business of intermediation, a business model that relies on trading profits could be under serious threat if this primary business is changed by IT.

To summarize, as the power of shared infrastructures and the ubiquity of IT-mediated spaces grow, increasingly complex matching can be done by information technologies. The scope of transformation this will engender depends on the extent to which automated systems can assess product quality and buyer preferences, and the extent to which parallel progress in information technologies increases the complexity of the products and services in question. This represents an important direction for future research.

4.1.2. How Do Platforms Alter Existing Business Models and Create New Ones? The shared infrastructures of increasing power that emerge as a consequence of the technological invariants often lead to the emergence of platforms whose importance and scope expands well beyond the confines of the IT industry. Loosely defined, these platforms are now some combination of channel access, functionality embedded in an IT system, physical assets, and associated business processes. Because of the modularity of IT, we call these agglomerations *platforms*—not just shareable, but which can be *built upon* by others. For example, Amazon.com has created a consumer commerce platform that, while performing the IT tasks associated with ordering and payment in electronic commerce, also includes access to millions of customers, processes for effective scalable direct fulfillment (a competency that Amazon was able to establish before anyone else), and the associated physical assets, like warehouses and trucking. This platform is the backbone of Amazon's online retailing business model. Further, it generates substantial high-margin platform revenues from corporate customers like Lands End and Target, as well as millions of smaller sellers who use the platform in exchange for a fee. It would not be surprising if Amazon continues to generate an increasing fraction of its revenues by providing such platform-based services to sellers and buyers in the future.

Whether a firm like Amazon should grow the portion of its business that provides platform-based services rather than making its platform a basis for proprietary competitive advantage in its core retailing business appears to be open for debate. This debate can be informed by recognizing that WalMart had the elements of a comparable aggregation of IT, best-in-industry fulfillment processes, and manufacturer relationships that could have been assembled into a platform for offline commerce, but which it chose to keep proprietary, much like American Airlines did with its SABRE system (Christiaanse and Venkatraman 2002). WalMart became the largest retailer in history, but its stock price has been flat or declining for many years now. The comparison with eBay, which has chosen to restrict its business to pure matching rather than creating a platform encompassing other trade processes, is also instructive. In contrast, ITC's eChoupal (Upton and Fuller 2004), which is far less IT-centric in the mix of assets it offers, has grown successfully in the last five years into a platform-based business for rural commerce, with a presence in tens of thousands of villages, leveraged and built upon by over 100 corporate customers who use the platform to deliver their products and services.

Challenges to and changes in business models do not have to involve platform ownership or trading off exclusive use with platform-based revenues. The existence of these shared infrastructures and their use by smaller businesses who can now access the resources once confined to Fortune 500 companies often causes fundamental changes in the demand patterns across industries. An empirical example of this is in the recent evidence of a long tail in electronic commerce (Anderson 2006, Brynjolfsson et al. 2006, Oestreicher-Singer and Sundararajan 2006). The use of these platforms also increases the importance of systems and methods for ensuring the reputation of smaller businesses (Dellarocas 2003, Ba and Pavlou 2002, Ghose et al. 2007). The latter topics are active areas of applied research in IS and beyond.

A related direction of future intellectual inquiry is based on a casual empirical observation: Many recent successful start-ups of the Internet era are distinguished by the fact that they rapidly established critical mass by creating and using a new platform, and followed this by monetizing the critical mass in related markets via an expansion of their business models. The best known success stories are Amazon.com and Google. The interesting question is whether there is a general pattern in how these start-ups manage to seize a white space, use it to acquire access to customers, and then expand to monetize their customer base. Open questions include MySpace, Facebook, and SecondLife.

4.1.3. What Determines Success with a Firm's IT Investments? Information technologies continue to be a growing fraction of corporate capital expenditure. There is substantial evidence of variance in the extent to which firms succeed with these increasingly large investments. The importance of the question posed here has been recognized for a number of years, and has been the focus of academic inquiry that draws from a variety of disciplines.

There are at least four known complementary answers to this question. The first focuses on the importance of choosing the right portfolio of IT investments (Weill 2003, Aral and Weill 2006) and managing this portfolio in a manner that is aligned with the risks and opportunities expressed in a business model. The second answer highlights the role of making the organizational and process investments that complement IT investments (Brynjolfsson and Hitt 2000). More specifically, there is a growing body of empirical evidence that firms who succeed with their IT investments do so because these investments are accompanied by appropriate changes in business processes, organizational structures, and employee compensation practices. The third answer relates to gaining user acceptance and adoption of the systems that comprise these investments, and instituting processes, cultures, and practices that facilitate such acceptance (Davis 1989). This theory has received widespread empirical support in the IS literature.[8]

[8] A related issue is whether companies with an IT-friendly CEO are more likely to succeed with their IT investments. A recent MBA student highlighted this point well with a question based on his experience, which was "Why do some firms embrace IT while others see it as a necessary evil?" An answer that would benefit from further inquiry relates to the importance of making IT investments an integral part of corporate strategy and creating an IT-friendly organizational culture.

The fourth answer is that success with IT investments requires effective IT governance (Weill and Broadbent 2003), which involves making decisions about technology that anticipate future demand, accommodate changing business needs, and align the capabilities of the IT investments with the firm's business strategy (Hoque et al. 2005). The emergence of shared platforms can quickly render firm-specific IT investments obsolete. A critical task of IT governance is making those investments that anticipate the emergence of increasingly powerful platforms, but offer the firm a real return on its proprietary investment, because there is unlikely to be any excess return from investments that are rendered obsolete by the emergence of shared platforms. These are difficult decisions, especially because IT infrastructure investments account for roughly half of all current IT spending.

A number of models that deal with the problem of reducing the risk of major IT investments have been proposed. An especially useful one is to view IT as creating future opportunities or returns that otherwise would not have existed, or, as a recent paper describes in detail, as creating digital options (Sambamurthy et al. 2003) when IT investments are made in stages. The recent explosion of large-scale business process and IT outsourcing is an example, because it tends to allow firms to mitigate infrastructure investment risks (although creating others). Indeed, as information is separated from its artifact and the power of shared infrastructures has grown, it has become increasingly viable to outsource IT investments, often to offshore locations. As technology-mediated spaces of interaction grow in their scope, managing such outsourcing can become more effective. As we discussed earlier, the technological invariants and their consequences also suggest that the ability to build and deploy large-scale IT-based systems has historically been commoditized over time. Although the complexity and modularity of IT may mean that a utility-like future is unlikely across the board, this raises tangential questions: Which IT investments should be proprietary and built in-house? Which investments should be owned, but based on shared platforms? Which investments should be outsourced and therefore converted into expenses? Put a different way, how should firms choose between making, buying, and leasing/outsourcing IT? Our technology-centric framework and its consequences suggest a growing importance of the answers to this question over time.

4.1.4. How Do Firms Effectively Get Value from and Govern Data? Innovation and creativity in the use and application of data for decision making are critical to success as a business executive. Data about interactions that are increasingly mediated by new IT-enabled spaces and e-commerce interfaces have the potential to make firms a lot more intelligent than they are today, because current manual processes often impede the flow and analysis of data. The more electronic the spaces of interaction between agents, and the more this interaction involves the transaction of digital goods, the richer and more accurate are the data trails created, and the greater the possibility of their intelligent interpretation and summarization in real time. What is knowable about individuals, business, and society increases tremendously as such data become available. Conversely, not recognizing the nuggets in the data puts a business at a significant disadvantage if its competitors have the infrastructure to do so.

However, richer data trails do not automatically imply better decision making. Making effective use of data is a management challenge, requiring the right technology decisions, processes, and a culture where decisions are based on and measured by data that relate actions to outcomes. Recognizing the links between internal and external data resources available to a firm, and the relationship of these linkages to decision making is critical to getting value from data. This is because prior managerial decisions often define the data available for future decisions.

Firms that derive value from their data often focus on investing in data resources while encouraging predictive modeling, active hypothesis generation, and testing.[9] They manage to squeeze more value out of their business processes through analytics and proprietary technologies. Research in machine learning and knowledge discovery from data gives us the ability to rigorously frame how we think about analysis of this kind (Dhar 1999). As spaces of interaction

[9] Indeed, as has been observed by an astute manager in a popular case on food retailing, analyzing data only about current products and customers is likely to lead to slow death. As the manager says, "If you pursue only dollar spinners with your POS system, your business will slowly contract."

become increasingly IT mediated, these data will be networked, and mining such data will be informed by emerging research that stems from IS, machine learning, and the science of complex networks.

The challenge in developing effective decision-making systems is in making data "liquid," or easy to transport, integrate, and analyze. Merely thinking of corporate data as an asset whose liquidity (the ability to convert data into useful information) defines part of its value is useful in itself. Although we have written about this topic in the past (Dhar and Sundararajan 2000), we are unaware of widely known theories that explain how to make information more liquid, and the broader organizational implications of information liquidity. This represents an important area for future research.

The explosion of data in business also elevates to the boardroom the issues of data governance, privacy, security, and the risks to business and governments that result from alternative policies and processes. A critical trade-off when making data governance choices is between the value of data as an asset and the potential liability its inappropriate use might impose. The case of AOL releasing its search records inadvertently in the summer of 2006 is an early illustration of this trade-off. A discussion of this case raises a number of related issues of privacy, responsible data use, and what is ethical in a business world where consumer intent is increasingly transparent. However, theories and frameworks for data governance are still in their infancy. Future academic inquiry into this increasingly important issue and its connection to the growing body of research on IT security policies would be useful.

The effective governance of data and its appropriate liquidity can inform a related question: What are leading and lagging indicators of organizational performance, and how can IT be used to identify the leading ones? For example, how do you construct internal measurement systems that provide useful information about the quality of earnings and other intelligence required to alert management to threats and opportunities that cannot be identified from the firm's reported financials—the lagging indicators?

4.1.5. Why Do Incumbent Companies Frequently Miss Large, New IT-Based Opportunities? Business history is replete with examples of companies that have missed a new business opportunity because of the emergence of a new technology to which they did not pay attention (Christiansen 1997). Often, this missed opportunity can lead to the loss of an industry leadership position. The explanation is often simple. New technologies satisfy different (and smaller) value networks[10] than the value network of dominant firms. The smaller markets are ignored early on because their size is insufficient to warrant the attention of large firms and because the dominant firms are listening too carefully to customers who are simply not interested in the smaller value network. The newer technologies often replace the existing ones, and when there is a shift in dominance, it is often too late for the older leaders to adapt to and deliver in the new market.

A recent example in financial intermediation is of online consumer-to-consumer payments. PayPal emerged as the dominant firm in the consumer-to-consumer space because it understood how to leverage IT to intelligently manage the unique risks associated with a new form of payment and settlement that was not so important in the business-to-consumer or business-to-business spaces. However, its success was also attributable to incumbent firms such as VISA paying attention to the needs of the larger customers in their existing value network—traditional and large online retailers—and perhaps not recognizing the opportunity in the newer consumer-to-consumer space that valued a different set of attributes until it was too late.

A similar conceptual basis defines why successful new IT platforms often emerge on the fringes. Historically, companies that accomplish successful platform entry start in niche markets, aim their products at technologically sophisticated consumers, and actively avoid head-on competition with an entrenched incumbent until their platform is sufficiently strong. Bresnahan and Greenstein (1999) explain why this "competitor-fleeing behavior" is a striking empirical regularity in the successful entry of new platforms over the last 40 years:

[10] A value network can be thought of in terms of the attributes of a product or service that customers want. Christiansen's example in the disk drive industry of a value network is reliability and speed, whereas an alternative one would be size and toughness.

> The complex and complementary nature of components in a computer platform means that it can take time for a new platform to work well for its users. As a result, a newly invented platform will be a weak competitor for established platforms. This weakness leads entrepreneurs making new platforms to flee competition....

This observation underlines a key (and perhaps fatal) strategic error that Netscape made by taking on Microsoft too early and drawing the incumbent's attention to its market before it had the resources for head-on competition.

In a sense, this fifth question can play an integrative role in a program of education because answering it requires an understanding of the nature and importance of platforms, the data that get managerial attention, and the imminent IT-enabled transformation likely to occur in the industry.

4.2. Technology-Centric Questions

The second set of questions flow from the consequences of the technology-centric framework of IT in business. These draw the boundaries around important areas of conceptual inquiry that may help answer current business questions, or those that are yet to emerge.

4.2.1. How Do the Unique Characteristics of Digital Goods Impact Business Models? The separation of information from its artifact across a number of industries leads to a unique (information goods) cost structure for such products, characterized by high fixed costs and near-zero variable costs. The pricing and production of these products is governed by economics that are quite different from those that define tangible goods. For example, firms often profit from massive bundling of digital goods (Bakos and Brynjolfsson 1999), and from allowing unlimited usage for a fixed price (Sundararajan 2004b), both radical departures from the theory of pricing traditional products.

This separation also makes information amenable to different forms of manipulation and electronic transport, which leads to an increase in the threat and prevalence of *digital piracy*, a phenomenon most recently visible when (digital) music was separated from its tangible artifact, the CD. Such a separation introduces a new set of strategic considerations relating to the management and granting of digital rights. Rather than being used anonymously under the guidelines set forth by intellectual property law, the rights associated with digital goods—rendering, copying, reselling, for instance—may be explicitly determined and controlled by their sellers. A central trade-off that this presents is between value and deterrence (Sundararajan 2004a). The deterrence of piracy is often linked to the managing of rights and the choice of a digital rights management platform. However, restricting the rights that lead to piracy also diminishes the value of a digital good, possibly to the point where its market collapses. As broadcast TV moves online and home video is separated from its physical artifact, the DVD, this trade-off between value and deterrence will be central in defining leadership and structure in other media and content industries.

4.2.2. Why Do Network Effects Pervade IT-Based Businesses and How Do They Alter Strategy? Network effects (an increase in value associated with an increase in usage or adoption) pervade IT-based business because of two consequences of the technological invariants. First, the value of platform-based products and services increases with their adoption. This is because their adoption leads to the independent development of additional modular applications and layers of functionality that can enhance the platform's value, and which often gets integrated into the platform over time. The multibillion dollar annual revenue stream that Microsoft has sustained from its Windows platform for many years can be explained quite easily by network effects of this kind. The number of devices whose architecture is platform based has grown over the years, and this move can be traced to the technological invariants—more powerful general-purpose devices running modular software. The transition of mobile phones from special-purpose hardwired devices to computers running sophisticated operating systems and applications is a recent example.

Second, the increasing mediation of spaces of interaction by IT makes the value of such spaces increase with their participation. Although network effects have always pervaded communication technologies like the telephone, the fax machine, e-mail, and instant messaging, their importance grows as the scope of

interaction between individuals is mediated further by virtual spaces like Facebook and SecondLife.

Network effects pervade IT-based businesses for many other reasons. As discussed earlier, matching of various kinds is increasingly mediated by an IT-based system. This leads naturally to stronger two-sided network effects (Parker and Van Alstyne 2005), which are central to why eBay has managed to sustain its competitive advantage in the online auctions that mediate a growing spectrum of business activities (Bapna et al. 2001). Network effects become more closely associated with IT as an increasing number of products derive their value from socially constructed content, which leads to an increase in value as social networks grow. Their importance is further highlighted by the growing popularity and business scope of peer-to-peer technologies, because a growth in the number of nodes (or users) in networks such as BitTorrent and Joost increases their quality (Asvasund et al. 2004).

Past academic research has recognized network effects, examined why they lead to path-dependent success (the occasional success of inferior technologies), and explored the possibility that higher industry concentration may be efficient. These are useful results for guiding competitive policy in IT industries. Qualitatively, there is also a clear understanding that the presence of network effects leads to a trade-off between openness and control of technology (Varian and Shapiro 1998). Open technologies are adopted more rapidly and value is created by a greater number of sponsors, but control allows firms that sponsor a technology to realize more of the value generated by its success. Concepts that inform strategy for launching new products that display network effects, the appropriate way to *seed* a network, and the right price path over the life of the product are still fairly nascent. An important recent development is the recognition that network effects are *local* in a growing number of IT-based products and services (Sundararajan 2007). As IT pervades a larger segment of the economy, the importance of such research is likely to grow over time.

Here is an example of the business importance of effective answers to these first two technology-centric questions. When software-based interfaces for rendering digital goods (like the iTunes music player, which renders the digital AAC files containing the music purchased from the iTunes store) become channels, the effective management of the digital rights associated with the products whose consumption and commerce they mediate becomes a crucial strategic imperative. Scale or geographic reach is less important. Similarly, the trade-off between the rapid growth that an open standard facilitates and the future value capture that a controlled standard yields determine the value and success that the channel will enjoy. The success of iTunes is explained most easily by its ability to make the right decisions on these two issues, in contrast with their predecessors and competitors. The example is provided to first underline the importance of research that eventually informs appropriate strategic choices about the effective management of digital rights. Prior research has highlighted and informed the trade-off between value and piracy that underlies the management of digital rights. Similarly, research on network effects has informed the trade-off between openness and control. However, making the right choice is more complex and nuanced than simply recognizing the trade-off. Future strategy needs to be informed by new research into the nature of digital rights; the evolution of intellectual property law in a digital economy where technology is subsuming roles that were historically played by the law; the evolution of standards, and empirical analyses of the relative advantages of openness and control.

4.2.3. How Does Human Behavior/Interaction Differ in Spaces Mediated by Information Technology? Answers to this question have been provided by many years of research into how organizational interaction is changed by the adoption of collaborative technologies like e-mail (Sproull and Kiesler 1986) and groupware (Orlikowski 1992). However, the implications of answers to this question are no longer confined to the organization. For example, the value of new social networking sites like MySpace and Facebook rests on the nature of interaction between their participants within this technology-mediated space, of their participants with the interface, and the associated data generated by such interaction. The scope of importance of the sociology of technology-mediated spaces grows tremendously when they form the basis for consumer-to-business or consumer-to-consumer interaction.

To summarize, the three technology-centric questions are already the subject of a substantial tradition of research within business schools and beyond. Each research tradition is at least 20 years old, and still vibrant. As the presence of IT-centric business school research that studies the transformational impact of IT on business and society grows (Agarwal and Lucas 2005), the importance of these foundations will increase.

5. Concluding Remarks and a Path Forward

Business school and industry leaders are unanimous about the growing importance of information technologies in business and society. However, there is a significant disconnect between this perceived importance and the presence of IT in business school curricula. Our inquiry over the last three years has been motivated by this disconnect. Our interviews with business school leadership explained some of the reasons for this situation, but did not suggest a solution. Instead, they identified the challenge of addressing the disconnect. In a nutshell, this challenge is to be rigorous, grounded in relatively invariant concepts that emerge from research, relevant to practice, and forward looking.

In thinking about this challenge, we have realized that the last four decades of research and practice have yielded principles that are useful in analyzing the effects of IT in business from both a managerial and research standpoint. From the research perspective, there are substantial and important questions whose answers will have significant consequences for the management of IT in business, for entrepreneurial activities, and in general for how wealth will be created in the future. From the managerial standpoint, there are now principles and implications that can offer executives input into their strategic choices about information technologies, how to think about them, and to manage them to achieve business goals.

As a response to this challenge, we have laid out a blueprint for education about IT in business. The frameworks we present are based on extensive qualitative information gathered from our interviews and from panels and workshops over the last three years. The questions and answers we have presented in §4 flow from our frameworks, and frame a program of education that aims at longevity and conceptual depth.

In any program of business education, the balance of emphasis between the three reasons that define our business-centric framework might vary across schools, depending on their composition and the anticipated career paths of their students. We have successfully designed and delivered an MBA course based on our blueprint—one-half on transformation, one-quarter on investments, and one-quarter on data and decision making.[11]

A central message of our paper is a call to integrate future academic research about IT in business more closely with the educational and classroom content of importance. There is already an impressive body of research that informs the program of education we have outlined. However, the nature and ownership of education about IT in business is still being defined. Making progress requires a clear perception of information technologies from a variety of perspectives. The questions we have identified stem from these perspectives and their answers come from a variety of reference disciplines, such as economics, sociology, computer science, and cognitive psychology. What brings these answers together in a useful way is a shared interest in and deep understanding of IT on the part of researchers who also possess a deep understanding of one or more of the other disciplines relevant to business. Perhaps this is why research in IS has often led other disciplines in writing about how IT will alter the answers to their fundamental questions. Successful future education about IT in business is likely to be strengthened by the creation, across many business schools, of interdisciplinary groups of diverse and active researchers, each of whom is grounded in a discipline of importance, but who share this interest in and deep understanding of information technologies.

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[11] An outline of our course is available at http://www.stern.nyu.edu/ceder/itbizsoc/.

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References

Agarwal, R., H. Lucas. 2005. The information systems identity crisis: Focusing on high-visibility and high-impact research. *MIS Quart.* **29**(3) 381–398.

Anderson, C. 2006. *The Long Tail: Why the Future of Business is Selling Less of More.* Hyperion, New York.

Aral, S., P. Weill. 2006. Generating premium returns on your IT investments. *Sloan Management Rev.* **47** 39–48.

Asvasund, A., K. Clay, R. Krishnan, M. D. Smith. 2004. An empirical analysis of network externalities in peer-to-peer music-sharing networks. *Inform. Systems Res.* **15** 155–174.

Ba, S., P. Pavlou. 2002. Evidence of the effect of trust building technology in electronic markets. *MIS Quart.* **26** 243–268.

Bakos, Y., E. Brynjolfsson. 1999. Bundling information goods: Pricing, profits, and efficiency. *Management Sci.* **45** 1613–1630.

Bapna, R., P. Goes, A. Gupta. 2001. Insights and analyses of online auctions. *Comm. ACM* **44**(11) 43–50.

Bresnahan, T., S. Greenstein. 1999. Technological competition and the structure of the computer industry. *J. Indust. Econom.* **XLVIII** 1–40.

Brynjolfsson, E., L. Hitt. 2000. Beyond computation: Information technology, organizational transformation and business performance. *J. Econom. Perspect.* **14**(4) 23–48.

Brynjolfsson, E., J. Hu, M. Smith. 2006. From niches to riches: Anatomy of the long tail. *Sloan Management Rev.* **47**(4) 67–71.

Carr, N. 2003. IT doesn't matter. *Harvard Bus. Rev.*

Christiaanse, E., N. Venkatraman. 2002. Beyond Sabre: An empirical test of expertise exploitation in electronic channels. *MIS Quart.* **26** 15–38.

Christiansen, C. 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* Harvard Business School Press, Cambridge, MA.

Cooley, T. 2005. Business education for the future. Mimeo, New York University, New York.

Davis, F. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quart.* **13** 319–340.

Dellarocas, C. 2003. The digitization of word-of-mouth: Promise and challenges of online reputation systems. *Management Sci.* **49** 1407–1424.

Dhar, V. 1999. The role of machine learning in organizational learning. T. Lant, Z. Shapira, eds. *Managerial and Organizational Cognition.* Lawrence Erlbaum Associates, Mahwah, NJ.

Dhar, V., A. Sundararajan. 2000. Maximizing information liquidity in electronic commerce. Mimeo, New York University, New York.

Dhar, V., A. Sundararajan. 2006. Does IT matter in business education? Interviews with business school deans. http://ssrn.com/abstract=912586.

Ghose, A., P. Ipeirotis, A. Sundararajan. 2007. Opinion mining using econometrics: A case study on reputation systems. *Proc. 45th Annual Meeting Assoc. Computational Linguistics*, Prague, Czech Republic.

Gurbaxani, V. 2003. Does IT matter? An HBR debate. *Harvard Bus. Rev.* (June).

Hamel, G. 2003. The quest for resilience. *Harvard Bus. Rev.* (September).

Hoque, F., V. Sambamurthy, R. Zmud, T. Trainer, C. Wilson. 2005. *Winning the 3-Legged Race: When Business and Technology Run Together.* Prentice Hall, Englewood Cliffs, NJ.

Lataif, L. 2005. The next generation of MBA's. *Financial Times* (November 14).

Lessig, L. 2000. *Code and Other Laws of Cyberspace.* Basic Books, New York.

Mendelson, H., R. Pillai. 1998. Clockspeed and informational response: Evidence from the information technology industry. *Inform. Systems Res.* **9** 415–433.

Newell, A., H. Simon. 1976. Computer science as empirical inquiry: Symbols and search. *Comm. ACM* **19**(3) 113–126.

Oestreicher-Singer, G., A. Sundararajan. 2006. Network structure and the long tail of electronic commerce. *Proc. 27th Internat. Conf. Inform. Systems*, Milwaukee, WI.

Orlikowski, W. 1992. Learning from notes: Organizational issues in groupware implementation. *Proc. 1992 ACM Conf. Comput.-Supported Cooperative Work*, Toronto, Canada 362–369.

Parker, G., M. Van Alstyne. 2005. Two-sided network effects: A theory of information product design. *Management Sci.* **51** 1494–1504.

Porter, M. 1979. How competitive forces shape strategy. *Harvard Bus. Rev.* (March–April).

Sambamurthy, V., A. Bharadwaj, V. Grover. 2003. Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quart.* **27** 237–263.

Sproull, L., S. Kiesler. 1986. Reducing social context cues: Electronic mail in organizational communications. *Management Sci.* **32** 1492–1512.

Sundararajan, A. 2004a. Managing digital piracy: Pricing and protection. *Inform. Systems Res.* **15**(3) 287–308.

Sundararajan, A. 2004b. Nonlinear pricing of information goods. *Management Sci.* **50**(12) 1660–1673.

Sundararajan, A. 2007. Local network effects and complex network structure. *Contributions to Theoret. Econom.* **7**(1).

Upton, D., V. Fuller. 2004. The ITC eChoupal initiative. Harvard Business School Case 604-016, Harvard University, Cambridge, MA.

Varian, H., C. Shapiro. 1998. *Information Rules.* Harvard Business School Press, Cambridge, MA.

Weill, P., M. Broadbent. 2003. *Leveraging the New Infrastructure: How Market Leaders Capitalize on Information Technology.* Harvard Business School Press, Cambridge, MA.