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Finding Value from IT Investments: Exploring the Elusive ROI in Healthcare

ABSTRACT

This article explores the historical IT value research, discusses its applicability to IT investments in healthcare, and highlights how it is challenged by several factors unique to the healthcare industry. The integration of historical IT value research with healthcare industry attributes provides an important context for understanding why the IT value proposition in healthcare has been so elusive. The article also poses a set of guidelines, which, based on the IT value research outside of healthcare, may assist in alleviating some of the current frustration with determining the value of healthcare IT investments.

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There is much about healthcare that is unique. As Jeff Goldsmith has observed: Healthcare services are not only the prototypical knowledge business, but also are perhaps the most complex product of our economy. More variability and uncertainty at the point of service exists in healthcare than in any other service in our economy.1 With such “variability and uncertainty” in the healthcare business, it is not surprising that identifying a return on investment (ROI) from healthcare IT presents special challenges. Whether labeled as the search for an ROI, “benefits realization,” or “benefit/cost analysis,” the task is essentially similar: we need to understand better where we can identify and measure the value from our information technology investments.

KEYWORDS

Value Return on investment (ROI) Healthcare IT investments
In recent years the combination of new types of IT investments (e.g., computerized physician order entry) and increasingly constrained sources of revenue (e.g., the Balanced Budget Act) have conspired to place information technology investments under a scrutiny they have historically avoided. While the Y2K phenomenon and what many have regarded retrospectively as its excessive IT spending certainly accelerated the process, the search for returns from IT investments has become an ongoing and inescapable challenge. But we need to differentiate what is “uniquely healthcare” and what is inherent in the nature of IT itself that makes valuation difficult.

The search for business value from IT investments is not new, and in fact has been an ongoing preoccupation of economic and management research outside of healthcare for almost a half century — at the macroeconomic level, across industries, and, more recently, at the level of the individual firm. Many recent discussions about ROI for healthcare IT have typically ignored this historical context and often conclude that finding value from healthcare IT investments is uniquely difficult and frustrating, without discussing why this might be the case, or what to do about it. Placing healthcare ROI discussions within the context of the historical search for IT value can minimize this frustration and hopefully enable us to develop a more fruitful approach to healthcare IT investments generally.

Brief Overview of Historical IT Investments in Healthcare

Investments in information technology in healthcare can be characterized by a series of phases, beginning in the 1960s with investments in financial systems — billing, general ledger, and payroll — which support the organization’s financial accounting and reporting. During this phase, IT investments were generally viewed as substitutions for labor costs, a fairly common initial stage for IT investments in a number of industries. Determining the value of these types of investments was clear and straightforward: if investing a dollar in information technology permits one to save more than a dollar in labor costs (e.g., through the elimination of clerical positions), then the investment is deemed to be “worth it.” The value to the organization stems from the fact that the financial resources invested in IT generated a return in the form of labor cost savings that were greater than the initial investment.

A second phase, starting in the late 1960s and carrying over into the 1970s, saw major initiatives by clinical departments to invest in systems that supported their internal activities — departmental systems for radiology, clinical laboratories, and pharmacy are important examples here. While the substitution of IT for labor continued to be important, the primary emphasis shifted to more efficient processing of patients and specimens, extending the ability of technical and professional staff to work more efficiently and effectively, and the ability to more easily generate clinical and management reports from data that was increasingly stored electronically.

Management reports were particularly important, since at that time hospitals were reimbursed for the services they provided on the basis of their costs. Departmental systems, with their ability to capture charges that were then sent to billing systems, produced the data that, through standardized “cost to charge ratios,” could generate the required cost reports.

In response to the shift in financial risk from payers to providers that occurred with introduction of DRGs, per diem reimbursement, and managed care in the 1980s, financial systems again became prominent with major investments in cost accounting and materials management systems. It was apparent that simply adding to the labor pool would not meet the challenge of developing and generating reports on the cost of doing business nor meet the task of managing expanding supply inventories.

In this second phase, information technology investments became mechanisms to permit the organization to engage in activities that simply could not be done by relying on staff with paper, pencils, or even calculators. Healthcare organizations had by this point passed from a simple labor substitution model into a model that focused more on enhancing the productivity of the labor force and on generating more accurate and focused data on the costs of doing business.

Entering the 1990s, attention turned to enterprise-wide clinical systems, including clinical data repositories and visions of a fully computerized electronic patient medical record. In this third phase, healthcare provider organizations were now challenged to make IT investments that were no longer labor substitution mechanisms, nor even primarily productivity enhancements for their employees. Rather, the focus became efforts to improve the quality of the product being delivered — attempting to meet goals of higher patient and provider satisfaction, increasing the safety of patient care, and reducing the risk and the cost of liability for medical errors. The end of the decade was highlighted by the publication of The Institute of Medicine’s

“W e need to differentiate what is “uniquely healthcare” and what is inherent in the nature of IT itself that makes valuation difficult.”
Each successive phase of IT investment in healthcare has produced both greater expectations and more complex systems environments into which IT investments are being made — probably none more so than the current phase with its potential (and real) impact on the provision of clinical care. With the added complication of significantly reduced reimbursement for care from both public and private payers, the pressure on healthcare industry managers to justify their information technology investments has increased significantly.

In comparison to other investments that healthcare leaders make, such as new facilities and medical equipment, the questions about which information technology to purchase and implement seem particularly challenging. New and remodeled buildings bring almost immediate results — more capacity to deliver more care to more patients, higher satisfaction from physicians and patients because of “updated” or “more modern” facilities, and even the possibility of a greater revenue stream from more or new types of patient services or perhaps rental income. The “value” of these investments is relatively clear, even if the measurement of the value accruing specifically to the investing organization is not.

“Value” in these examples is quite simply the justification for expending the resources. In the healthcare industry, the value that is returned from an investment can be described as supporting the attainment of at least two basic goals:

- To help sick people get well and minimize the possibility that well people will get sick
- To accomplish the first goal in a manner that sustains the organizational contexts through which the objectives of that first goal are carried out (e.g., hospitals, physician practices, long-term care facilities, etc.)

These goals are certainly much less measurable than the goals that exist in other industries, namely financial profits and returns to shareholders. Nevertheless, in most cases the value from investments made by healthcare managers can be described primarily in terms of these two goals.

To the extent that investments in information technology support the attainment of these goals, then we can say that these investments return value to the healthcare organization. But the measurement of information technology’s contribution to the attainment of these goals is elusive, in part because there are at least three different basic measures or “return on investment” measures that are commonly used in financial models to determine value:

- Will this investment generate specific and direct reductions in labor cost or increases in revenue for the organization? (Phase 1 Investments)
- Will this investment result in an increase in the productivity of the organization’s labor pool, which may either enable the organization to perform the same amount of work with less labor or, to avoid future cost increases, enable a constant level of staff to perform a larger volume or more complex tasks? Further, will this investment enable the organization to generate more accurate and timely management reports? (Phase 2 Investments)
- Will this investment result in an improvement in the quality of the product or service being offered, an increase in the satisfaction of the organization’s constituents (either internal, such as employees, or external, such as customers) or a reduction in the liability or risk of producing a defective product or service (the “error reduction” strategy)? (Phase 3 Investments)

Figure 1 provides a graphical representation of these different types of investments and the relative ease with which the return on investment can be measured.

The measurement of information technology’s value within each of these phases has been systematically explored outside of healthcare, as other industries have experienced similar IT investment phases as well as similar pressures to measure the value of their IT investments. A brief review of each of these measures of value provides an important perspective on those facing these challenges within healthcare. However, it is important to look at information technology investments more generally first, since IT investments create an organizational asset that is, in some ways, fundamentally different from the assets created by other types of investment.

**IT Investments Create a Different Kind of Asset**

Firms in every industry make investments to create assets, which in turn generates revenue streams back to the firm, enabling it not only to sustain itself, but hopefully to grow and to provide financial returns to owners or shareholders. Firms in the healthcare industry are no exception to this process. Hospitals, long-term care organizations, physicians (whether incorporated as individual entrepreneurs or as groups) each seek to make investments, which will maintain revenue streams and sustain their organizations over time.
When this process creates new facilities, adds equipment, or substitutes computer hardware and software for manual processes, the value generated is relatively clear and easy to understand. But when an organization invests in information technology to enhance quality or convenience, the value is more difficult not only to identify, but to measure as well. In large part this is due to the fact that investments in information technology create an asset that is truly different from other assets (e.g., buildings and equipment) that organizations have traditionally created and understood.

Moody and Walsh, in their exploration of the value of information, developed a set of general principles that govern the behavior of information as an "economic good," and in fact distinguish information assets from other more traditional types of assets. Their approach is particularly helpful to our discussion of IT valuation in healthcare since it highlights why comparing the value from information technology investments with the value of other investments is difficult — in any industry. And since these IT assets are different in important ways, determining returns from IT investments can be a more elusive process. Two of Moody and Walsh's more important principles, with particular relevance to healthcare, are:

- Information is (infinitely) sharable, in that "it can be shared between any number of people . . . without consequent loss of value to each party." Most assets lose value when shared among several parties, since the total value of the asset is allocated in some proportion to each party.
- The value of information increases with use, in contrast to most assets, which actually exhibit "decreasing returns to use," i.e., they decrease in value the more they are used. The depreciation of buildings, for example, is the accounting mechanism designed to capture this decrease in value.

Within the healthcare industry, much of the motivation for electronic databases or medical records for clinical data resides in the fact that paper records simply cannot be shared easily among the increasing numbers of people who appropriately need to see and use the data. Information technology investments enable an increase in the availability of medical records to multiple users, and therefore enhance their value for diagnosis, treatment, and in some cases, research. This virtually infinite "sharability" of electronic medical records is a key component of the value that information technology brings to healthcare.

On the other hand, as Moody and Walsh note, information assets do behave in at least two ways that make them similar to other organizational assets:

- Information is perishable in that its value tends to decrease over time; information on recent events, for example, is typically more valuable than that which relates to events in the distant past — except of course for historians.
- The value of one set of information increases when combined with other sets of information, since comparisons and combinations of information can provide insights that a single set of information, viewed on its own, cannot.

Information in the healthcare industry exhibits these principles to a great extent. Recent clinical information on a patient is generally more valuable in determining the state of the patient’s health than information that is several years old, except in situations in which the physician is looking for historical comparisons or patterns. In addition, clinical data from individual patients can be combined in various...
ways to enhance its value. For example, we can learn more about diseases by grouping patients by type (inpatient vs. outpatient), location, and diagnosis (if interested in patterns for particular types of illness), type of medications prescribed, and in relation to diagnosis, treatment protocols, and outcomes, differentials among physicians in terms of therapeutic interventions for similar diagnoses, and so on.

To Moody and Walsh’s work, however, we would add one other principle that is perhaps unique to healthcare information technology, particularly with regard to individual clinical data. In most industries, investments are intended to create assets that are controlled by the organization. Control in this context means “the capability of the organization to benefit from the asset, to deny or regulate the access of others to that benefit.”13 In organizations outside of healthcare, this test of information as an asset is usually met. Organizations create databases on themselves, their employees, their operations, their customers, and their competition that is considered proprietary to the organization itself.

However, healthcare is different in that clinical data collected by healthcare organizations, for example, does not legally belong to the organization. As clinical data collection, storage, and use become a primary focus of healthcare IT investment, this “lack of control” becomes a complicating factor in our assessments of value.14 In this case, information technology investments are creating assets that do not belong to the organization that made the initial investment, so the value of the investment to some extent resides outside the organizational boundaries. This is truly at variance with how financial professionals typically think about asset creation.

In summary, information technology assets are infinitely sharable, increase in value with use, decrease in value over time, increase when multiple data sets can be combined, and increasingly contain content that is owned by someone other than the organization that created the asset. With these principles in mind, we next turn to a review of the important contributions of IT valuation outside of healthcare.

**IT Valuation Outside of Healthcare**

From Thomas J. Watson’s now famous comment in the late 1940s in which he projected that it was likely that he could only sell “3 or 4 computers,” to Robert Solow’s observation that “we see computers everywhere except in the productivity statistics,”15 — a comment that became known as the “productivity paradox” — many notable businessmen, economists, and others have wondered about the value of making investments in computers or in information technology more broadly.

The phases of IT investment that we identified earlier for healthcare IT investments, from labor substitution to productivity improvements to enhancements in product quality and service, parallel the types and sequence of IT investments made in other industries. While labor substitution has been of historical interest, some of the most extensive work in IT valuation has been done in productivity assessments.16 This is due to the historical assumption that the real rationale behind IT investments has generally been the desire to improve productivity, which over the longer run is a major contributor to economic growth.

**Phase 1 Investments: The Substitution of Information Technology for Labor.** In the earliest stages of information technology investments, the most common type of investment is one which substitutes computing capability for manual labor.16 Most industries, including healthcare, have followed this model. A number of routine activities, including the processing of transactions (e.g., patient bills), and the storing and retrieving of data, can be performed using electronic technology and, in the process, literally replace large numbers of file and accounting clerks.

While most organizations have already passed through this phase of IT investment, healthcare is still finding opportunities for labor substitution in areas such as clinical laboratories (with the introduction of robotics systems that substitute for medical technicians) and will probably do so in the future as imaging systems replace both medical records clerks and film file libraries. Of all types of IT investments, measuring the value of those that substitute IT for labor is probably easiest and best understood.

**Phase 2 Investments: Enhancement of Labor Productivity.** In the 1980s and early 1990s, economists became interested in the potential contributions of information technology investment to labor productivity. This was due in large measure to two observations: (1) A decrease in the average rate of growth in U.S. labor productivity beginning in the early 1970s, and (2) An increasing awareness that companies were beginning to make significant investments in information technology, especially with IBM’s introduction of its desktop personal computer in 1981.
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Economists observed that the growth in U.S. labor productivity averaged almost 5 percent per year over the entire period from the end of World War II until the early 1970s. At that point, however, productivity across the U.S. economy began to stagnate, averaging about 1.4 percent per year. During the period 1974-1995, economists determined that productivity growth was only increasing at an average rate of 1.4 percent per year, rebounding somewhat to an average rate of 2.5 percent between 1996 and 2000.20

In the same general time frame, as noted in recent research by McKinsey and Company, “the rate of nominal business investment in information technology surged to 17 percent per year, from its 1987-1995 rate of 9 percent.”21 From this data, it was assumed that even with new and increasing investments in information technology, for some unexplained reason productivity was not only not keeping pace, but had actually decreased from previous levels — hence Solow’s “productivity paradox.” Measuring productivity increases due to IT investment, however, is much more difficult than measuring IT investment as a substitute for labor dollars. We are no longer a manufacturing-based economy, and measurement tools developed in and applicable to that era are simply not adequate for measuring productivity in a services-based information world.

But with the surge in IT spending and the economy-wide productivity rebound after 1995, there was hope that the paradox had been resolved and that at last economists could conclude that IT investment was in fact contributing to productivity. As one economist noted:

Analysis of the industry-level data reveals that a broad productivity resurgence took place after 1995, with all principal sectors and a majority of industries posting productivity gains. The analysis also shows that the industries experiencing the largest productivity acceleration in the late 1990s were the producers and most intensive users of IT — a finding that provides direct evidence of information technology’s role in the U.S. productivity revival.22

Other research has supported these conclusions and emphasized the importance of understanding both the lag effects of IT technology investment and the importance of adapting organizational workflow to take advantage of IT investments.23

Simply investing in IT does not on its own, however, produce gains in employee productivity. Other “intervening” factors seemed to be operating that were difficult to identify from strictly quantitative data. While McKinsey’s research confirmed the contribution of IT investment to productivity, they identified another important contributor to value IT investment value:

In short, IT does matter, but its ability to impact productivity depends upon how it is employed. When tailored to sector-specific business processes, deployed in an appropriate sequence, and co-evolved with managerial innovation, its impact on productivity and, in some cases, profitability, can be large.24

Simply making an investment in IT, therefore, is not sufficient to achieve value. Organizations must change their underlying business processes in order to see gains not only in productivity, but also in their IT investments in general. IT investment therefore serves as an “enabler” for value, but on its own cannot be expected to create the kind of value that can come from combining it with changes in an organization’s underlying business processes.

Phase 3 Investments: IT Investments to Improve Quality of Service and Product. In addition to the realization that the value generated by IT investments is really obtained when IT is viewed as an “enabler,” we are also realizing that the measurement of this value is very difficult. As Brynjolfsson and Hitt have noted, “In today’s economy, value depends increasingly on product quality, timeliness, customization, convenience, variety, and other intangibles.”25 IT investments in general, across industries (but particularly in the services industries), have a difficult time with value measurement due to their dual nature of being “enabling” and attempting to measure an impact on “quality, timeliness, customization, etc.” — each of which can represent a new dimension to either current or new products or services.

In part this is due to the fact that information technology investments are part of a broad category of investments economists have called “general purpose technologies,” technologies whose value comes not directly from the investment itself, but instead from opening up “new opportunities”26 and from facilitating “complementary innovations.”27 In many cases, when we think we can recognize the presence or absence of these “intangibles,” we generally consider them to be valuable attributes, and even recognize that IT investments can enable them to occur. But it is also evident that, in this third phase, the dynamics of value and measurement are very different from the previous phases.

While investments made in Internet tools and capabilities (e.g., the proliferation of hospital and payer web sites and patient and health-focused portals) are considered by some as almost revolutionary, what is most interesting about Internet investments is their role as yet another IT “enabler,” albeit one that can potentially have an impact spreading across all three IT value dimensions:

- As labor substitute, when patients or plan members utilize a web site or a personal portal to access either their own or the organization’s data, thus diminishing the
need for staff to answer phone calls or letters.

- As productivity enhancement, providing physicians with remote access to patient data, or having patients enter demographic or financial data prior to a visit.
- As an enabler, improving the “quality, timeliness, customization, convenience, variety” of healthcare products and services by providing web-based access to schedules, health information, and even one’s own personal health-related data.

As if the difficulties of measuring the value from IT investments regardless of industry were not sufficiently challenging, we next turn to a set of attributes unique to the healthcare industry that add even more complexity to the process.

**Healthcare Industry Attributes That Challenge IT Valuation**

The valuation of IT in the healthcare industry is confronted by two significant attributes that distinguish it from other industries: (1) the industry’s historical structure and governance process, and (2) the mechanisms through which customers pay for services.

**Organizational Structure and Governance.** In the corporate world generally, those who decide what products and services to produce and deliver, those who actually manage the production and/or delivery process, and those who market the products and services typically work within the same corporate structure. Over 20 years ago, Michael Porter described this set of processes as a “value chain,” in which each step of the process from the acquisition of raw materials to the final production and distribution is carried out within the same governance structure. Even when a corporation decides to outsource some portion of its value chain, presumably to add value to a particular part of the chain, the decisions about what is produced, who is to produce it, how it is marketed, and how it is to be distributed remain within a single governance structure.

The healthcare industry, however, is fundamentally different. Using Porter’s value chain approach, it is evident that significant portions of healthcare’s value chain are provided by fundamentally different governance structures whose interrelationships and financial incentives seem strangely out of synch.

Figure 2 illustrates those four structures:

(1) a provider facility with its staff of caregivers, (2) physicians, (3) the payer(s), and (4) the patient (not strictly a “governance structure,” but distinguished clearly as an entity separate from the other three).

Each of the three major governance structures (facilities, physicians, and payers) has distinct histories and cultures that have shaped not only their role within healthcare’s “value chain,” but more significantly their historical sense of independence from each other. Indeed efforts in recent years to merge these entities under one form of corporate structure or another (e.g., hospitals purchasing physician practices, hospitals becoming payers, and payers employing physicians) have, with few exceptions, been singularly unsuccessful.

In no other industry does one find a value chain in which the major components are both necessarily integrat-ed to produce the final product or service, yet separate organizationally, culturally, and even in terms of financial incentives. In healthcare, those with the expertise to deliver the industry’s product or service are separated from the setting(s) in which the product or service is typically delivered and are, in turn, separate from those who purchase the product or service, and finally, separate as well from those who pay for the service.

**Paying for Healthcare Services.** In most economic transactions, the customer who receives the benefit of the goods and/or services purchased is expected to provide payment for receiving them. Whether purchasing a car, a house, a piece of furniture, or toothpaste, the basic model
underlying the economic transaction is the same. In healthcare, however, the basic economic model underlying the payment for care is fundamentally different, with a “third party” reimbursement structure that is unparalleled in any other industry.

Nowhere else do customers receive high-quality service for which they pay only a marginal portion of the cost (through copays and deductibles). The current reimbursement structure linking payers, providers (both physicians and hospitals), and patients (see figure 2) permits those who receive the value of IT investments (particularly improvements in the quality of service) to avoid in large measure making any direct payments for those benefits.

Another challenge beyond value measurement is the fact that many times the value of improved service and product quality, which might be enabled by IT investments, does not in healthcare accrue to the investing organization. In most industries, companies seek to recoup their investment through price differentiation. In other words, if a company makes an IT investment that enables an improved product or service, they would expect to charge a higher price than the competition and, in this way, recognize the value of their investment.

The problem in healthcare is that, while IT investments may improve the quality of products or services, the value accrues not to the investing organization (e.g., a hospital) but to the patient (who in many cases is only paying a marginal amount for the service) or to the payer organization (who might see shorter patient stays, fewer illnesses to pay for, etc.). Using the model from a recent report on the business case for healthcare quality, we can conclude that, while there is a social and an economic rationale for making IT investments to improve the quality of healthcare services or products, the business case, using customary ROI methodologies, is not only more difficult, but may in fact be impossible to make. As the study notes, “It is striking that in all cases where the investing organization is a provider, and even when the innovation is effective for patient care, the business case is unfavorable.” If we cannot make a business case for improvements in the quality of care provided by a provider organization, it will surely be difficult to make the business case for making IT investments intended to achieve that same objective.  

Guidelines for IT Decision Makers in Healthcare

Decision makers in the healthcare industry face difficult choices when confronted with the myriad of investment opportunities presented by operations managers, physicians, nurses, IT professionals, finance professionals, and even board members. In the absence of sufficient funding to make every investment (and there seldom is), decision makers look to “rules of thumb” or summary measures in their attempts to sort out the best investments from the simply better investments, never mind the bad ones. Return on investment (ROI) calculations can provide a convenient, common denominator for comparing investment opportunities — provided the returns can be quantified, the investment resources fully estimated, and even the investments themselves amenable to comparison in similar terms.

The conclusions we draw from our research help us understand why such ROI efforts in healthcare have to date been so elusive:

- Information technology investments produce assets that are fundamentally different from other types of assets.
- The nature of the investments themselves, particularly as Phase 3 investments, focusing primarily on improvements in service and product quality and customer satisfaction, are more complex and their value therefore less measurable that what hospitals have been able to do in earlier phases.
- The valuation of “Phase 3” IT investments even outside of healthcare is also challenging due to the nature of the investment itself, unrelated to the particular industry in which the investment is being made.
- The organization, structure, and payment mechanisms currently in place in the healthcare industry add even more complexity to the valuation of IT investments.

With these conclusions in mind, we have developed a set of guidelines to aid not only in the education of the decision makers about information technology investments, but to assist in the process of comparing IT investment opportunities.

1. Recognize information technology investments as “general purpose technologies,” in which the investment itself must be complemented by changes in organizational processes in order to deliver the greatest value.
2. Recognize that, even though investments in information technology create new assets for the organization, the nature of the IT asset is fundamentally different from most other assets organizations invest in, and we need to adjust our investment thinking to account for these differences.
3. Recognize that, under the current reimbursement process, the benefits of information technology investments in healthcare do not accrue only, or in some cases even significantly, to the entity that makes the investments. If physicians, patients, and payers benefit from these investments, we need a mechanism for them to contribute to the investment at the outset or subsequently through different reimbursement or payment models.
4. It is not that you cannot find or calculate a return from an IT investment that is most important; it is that these
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Types of investments have clear and definable value and that the terms of that value must be understood in the context of how IT investments create value more generally (even outside of healthcare), and the unique challenges of finding this value are not only the province of the healthcare industry, but of other industries seeking value from similar types of IT investments.

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References
7. At one time, these goals were thought to be the only acceptable goals in the industry, since much of the care provided was done within the context of nonprofit organizations (e.g., hospitals). Although individual physicians and nursing homes were early adopters of for-profit models, only in recent years has the for-profit model been extended to hospitals.
9. See reference 8, p. 4.
10. See reference 8, p. 5.
11. See reference 8, p. 6.
13. See reference 8, p. 3
14. While patients do sign waivers to permit their data to be shared with payers, for example, their clinical data residing in providers’ databases remains under the patient’s legal control. Recent HIPAA regulations have reinforced the sense of a patient’s ownership over his/her medical records.
17. As noted in Steindel, C., and Stiroh, K. J., “Productivity: What Is It, and Why Do We Care About It?” Federal Reserve Bank of New York Research Paper, April 12, 2001, “If labor productivity were to grow at 1.5% (the average rate from 1973 to 1995), output per hour would rise by 35% after 20 years. Growth of 2.7% (the average for 1995-1999) implies that it would be 70% higher after 20 years. Clearly, the rate of productivity growth can have an enormous effect on real output and living standards . . . and can serve as a good proxy for growth in per capita income and rising living standards.” p. 1.
22. See reference 19.
23. For an excellent summary of this issue, see Brynjolfsson, E., and Hitt, L. M. “Beyond the Productivity Paradox: Computers are the Catalyst for Bigger Change.” Communications of the ACM, August 1998, 41, 8.