Assessing the value of IT investments has stumped managers and academics for years. If viewed as a commodity input, however, IT should be measured in the context in which the investment takes place.

Although profit-seeking firms continue to invest in information technology (IT), the results of the empirical search for IT value have been bafflingly mixed—-even Nicholas Carr and other leading pundits to argue that IT has become a commodity input that, from a strategic standpoint, “doesn’t matter” [1]. According to Carr [2], “It remains difficult if not impossible to draw any broad conclusions about IT’s effect on the competitiveness and profitability of individual businesses... companies continue to make IT investments in the dark, without a clear conceptual understanding of the ultimate strategic and financial impact.”

A growing body of new work [5–7] builds on the view of IT as a commodity input to construct some of the missing links between IT investment and financial impact. This work develops analytical models that

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1Whenever there is a large shift in the relative importance of a major resource, it is natural to focus on the value and role of that resource. Three examples are labor (in the early 1800s), energy (in the 1970s), and IT (since the 1980s). Motivated by the increasing role of capital relative to labor, economists like Ricardo and Marx first equated the value of a good with the value of the labor required to produce it. Modern economists reject that notion in favor of the view the value of a good is determined by the cost of all of the inputs and the preferences of the consumers interacting in a market. However, society continues to be fascinated with the notion of assigning the value generated to a single input du jour. In recent years researchers and practitioners have sought to empirically demonstrate to managers, consumers, and politicians that the ever-increasing level of IT investment is not some awful mistake.

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address the logically prior theoretical question: How does IT matter when it is a commodity input? These models demonstrate that well-managed, profit-maximizing firms should not necessarily expect that IT investments will improve measures of business value (for example, profits and productivity) or even move them in the same direction since the directional impact of IT investments on business value depends critically on three factors:

- The type of product development the IT supports (digital products vs. traditional products);
- The market structure in which the firm competes (monopoly vs. competition); and,
- The type of IT in which the firm invests (design tools vs. production/distribution tools).

Therefore, it is not surprising that the empirical findings on IT value have been so mixed. These models will help structure the important debate on IT value and, in turn, will enable the interpretation of past empirical findings, guide future data collection, and provide IT managers with the appropriate interpretation of business value metrics for IT investment decisions.

**Modeling IT Value**

Returning to the basics and exploring IT value from a theoretical perspective, these models examine the changes in business value profit-seeking firms should expect from specific IT investments in alternative market environments. This work develops a series of duopoly models of quality-price competition and a series of monopoly models of quality-price choice in order to examine the impact of IT investments on firm profit, firm productivity, and consumer value.

These models are solved for four cost functions, where each function represents a different product category, leading to a 2x4x6 comparison [(monopoly, duopoly) X (four product categories) X (six output measures)] of the impact of IT investments on economic performance. Here, we summarize the impact of IT investments that support the development, manufacturing, and distribution of two product categories—digital products and traditional products. Several of these results are counterintuitive and, as such, it is imperative that IT managers understand these relationships when making and evaluating IT investment decisions.

The IT value models are characterized by the following assumptions:

1. IT is a commodity input that is readily and cheaply available to firms.
2. IT investments directly improve the cost efficiency of the firm.\(^3\)
3. Improvements in cost efficiency enable new firm strategy choices regarding product quality and price.
4. The business value, as measured by profits, productivity, and consumer value, resulting from the strategic choices is constrained by the market structure in which firms compete.

Standard economic techniques are used to solve these analytical models\(^1\) [see 6].

**Product categories.** We consider IT investments made by firms that produce either digital products or traditional products. Digital products such as software applications and online content are characterized by high fixed design (first copy) costs but near-zero unit production costs for additional copies. Fixed costs do not depend on the number of units produced but do include the cost of research and development and intellectual property (for example, patents) for the product. On the other hand, traditional products such as automobiles, pharmaceuticals, or financial services are characterized not only by substantial fixed costs but also by positive and significant unit production costs, which include the cost of manufacturing, distribution, support, and maintenance.

\(^1\)One reason for the mixed empirical findings on IT value is that studies have not effectively differentiated among (and often confuse) the goals of increasing production efficiency, improving product quality, and increasing firm productivity. Efficiency improvements are realized when IT investments enable a firm to produce a given product (of given quality) at lower cost (or fewer resources). Quality improvements are realized when IT investments lead to the creation of new products, or new features for existing products, which directly increase human desire to consume those products. Productivity improvements are realized when IT investments lead to an increase in the ratio of output value to its related input value. Our work illustrates the complex, and sometimes counterintuitive, interaction among production efficiency, product quality, and firm productivity and the resulting impacts on firm profits.

\(^2\)The models are analyzed by solving for the subgame perfect equilibrium at each stage of the competition. After solving for the equilibrium values, comparative static analysis is used to examine the impact of different IT investments on firm strategies and various measures of business value.
Market structure. We consider IT investments made by firms under two different market structures—monopoly and competition. Monopoly or near-monopoly power may be acquired naturally in the market through creation of standards, network externalities, economies of scale, location, or ownership of unique resources or may be granted by the government using patents or other legal means. Indeed, it is the presence of significant monopoly power, not the absence of entities attempting to compete, that determines whether or not a firm should be considered a monopoly; thus, despite the attempt of Yahoo or others to compete for online consumer auctions, eBay can be considered a virtual monopoly. Similarly, Microsoft may be considered a virtual monopoly in the area of operating systems. However, our work does not apply to monopolies in which the government retains regulatory control of the product quality and price, as has traditionally been the case in electric and other utilities.

On the other hand, most markets are characterized by some level of competition among firms. Economists often consider formal models of duopoly competition to examine the strategic interactions where firms possess some level of market power. Table 1 presents examples of industries that fall into each of the four combinations of market structure (monopoly, competition) and product categories (digital products, traditional products).

IT investments. We consider the business value of two types of IT investments—design tools and production tools—in the four contexts presented in Table 1. Firms that produce in either product category (digital products or traditional products) may use IT investments in design tools to lower the marginal cost of product design and thus to improve the efficiency of the firm's research and development capability. For example, the strategy of large pharmaceutical companies is to invest heavily in the design and development of new drugs that will qualify for patent protection. Since the early 1990s companies such as Bristol-Myers Squibb Co. and Pfizer Inc. have invested millions of dollars in combinatorial-chemistry technologies to improve their marginal drug design cost by automating the drug discovery process. These technologies can “…create thousands of chemicals almost overnight by mixing and matching common building blocks…” [4]. Although these technologies have been slow in generating FDA-approved drugs, they have “…helped improve some drugs that were found by more traditional means…” [4].

Table 2 illustrates, as derived in our models, the expected directional impact of investments in IT design tools and IT production tools on product quality, firm profits (difference between revenues and production costs), firm productivity (ratio of revenues to production costs), and consumer value (difference between consumers’ willingness to pay and price). An IT investment may either have a positive impact, a negative impact, or an impact that depends on the model parameterization. For example, consider firms competing with a digital product that make an IT investment in design tools (see Table 2, Column 1, Rows 5–8). This investment will lead to increases in
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product quality and consumer value and decreases in firm productivity. However, the directional impact of design tools on firm profits depends on the level of product differentiation between firms and the level of cost efficiency.

**Critical Findings**

*IT investments in design tools or production tools should lead to improvements in product quality and consumer value.*

The impact of IT investments on product quality under the four combinations of market structures and product categories are presented in Table 2 (Rows 1 and 5) while the impacts on consumer value are presented in Rows 4 and 8. These results illustrate that any IT investment that improves production efficiency will lead profit-maximizing firms to improve product quality in all cases. In addition, this IT-enabled quality improvement increases the net benefit for consumers even in cases when a higher price is charged for the product and when a firm acts as a monopolist.

*IT investments in production tools should increase firm profits and firm productivity.*

The impacts of IT investments in production tools to support the development of traditional products are presented in Table 2 (Column 3). The underlying belief that IT investments should improve business value has driven much of the empirical effort to resolve the IT productivity paradox and the IT profitability paradox. Finding 2 supports this underlying belief for IT investments in production tools. However, as we will see, Findings 3 and 4 do not support this belief for IT investments in design tools.

In the case of monopoly, *IT investments in design tools should increase firm profits but decrease firm productivity under both product categories.*

The impact of IT investments in design tools on firm productivity are presented in Table 2 (Column 1, Row 3 and Column 2, Row 3). This finding suggests it is reasonable to expect a profit-maximizing firm to alter its strategy (or product quality and price decisions) in a way that reduces firm productivity. We illustrate the intuition behind this finding with a hypothetical example. Consider Microsoft, a firm that exerts considerable market power in desktop operating systems. Assume a set of design tools (for example, CAD systems, prototyping tools) is made readily available to Microsoft and these tools lower the marginal cost to Microsoft for designing a better quality product to offer to the market. If consumers are sensitive to software quality, Microsoft would be able to charge a higher price and still realize an increase in the demand for the software. Since more software would be sold at a higher price, Microsoft's revenues would increase. In addition, the improvement in software quality would lead to an increase in total production costs despite the IT-enabled reduction in marginal design costs. Overall, Microsoft would realize an increase in profits (see Table 2, Column 1, Row 2) because the increase in revenue is greater than the corresponding increase in total costs. However, Microsoft's total costs would increase by a larger percentage than revenues, resulting in a decrease in productivity (see Table 2, Column 1, Row 3).

In summary, IT investments in design tools, if leveraged optimally, are likely to increase total production costs and lower firm productivity. However, profit-maximizing managers at Microsoft should not be concerned because these same investments increase (and, if fact, maximize) profits and increase consumer value. If Finding 3 holds, an empirical study of IT value at Microsoft would conclude that although an investment in design tools may improve the efficiency of the product design process, it may also hinder productivity. While a decrease in productivity may be interpreted by the casual observer as a negative outcome, in fact, it is consistent with profit-maximizing behavior.

In the case of competition, *IT investments in design tools may, unlike the monopoly case, increase or decrease firm profits.*
This finding is presented in Table 2 (Column 1, Row 6 and Column 2, Row 6) and demonstrates that, in the case of IT design tools, the so-called IT profitability paradox is not a paradox at all, but an economically rational and predictable outcome. If the firms produce highly differentiated products then each firm enjoys substantial market power, enabling each firm to leverage its IT investments to improve profitability. This result is consistent with the profit gains that monopoly firms should expect when investing in IT design tools (see Finding 3).

Alternatively, if the firms produce highly substitutable products then each firm possesses less market power. In the absence of collusive behavior the firms will compete in product quality improvements but will be less able to gain competitive advantage and improve profitability. In fact, given that IT is a commodity available to all firms, firms are compelled by strategic necessity to compete in product quality improvements in this case. According to Clemons [3], the idea behind strategic necessity is that “instead of becoming a source of lasting competitive edge, most strategic information systems become new and essential aspects of doing business... that is, profits will be competed away. Since the key resources of management information systems (MIS) applications are commodities available to all competitors, all competitors with similar MIS strategies can develop similar systems and benefits such as reduced costs or improved service.”

Clearly, when the products are highly substitutable both firms would be better off in terms of profits if they colluded to not invest in design tools in order to avoid a negative profit spiral. However, consistent with most competitive environments, any firms engaging in such legally unenforceable agreements may find themselves in a “prisoner’s dilemma.” That is, a competitor may violate the agreement, resulting in an even worse outcome for the non-investing firm.

**Implications**

The major objective of individual businesses is to generate profits by reducing production costs, improving product quality, improving firm productivity, and increasing consumer value. Much of the IT literature is focused on empirically examining ways IT investments may accomplish these goals. However, while it may be necessary for firms to pursue IT investments due to competitive pressures, strategic necessity, or firm survival, our work demonstrates these same IT investments may not result in improvements in traditional measures of business value.

Our work adopts the view of IT as a commodity input where investment in IT does not, in and of itself, create a market advantage for any one firm. Interestingly, while managers should expect significant improvements in business value from investment in production tools, they should not expect that profits or productivity will necessarily increase or that production costs will necessarily decrease after investments in design tools. Although managers may be inclined to set goals of reducing costs and improving productivity for all its IT investments, such a narrow view of business value may lead to underinvestment in product quality and, in the end, sacrifice profits.

The work summarized here grapples with the theoretical relationship between IT investment and economic performance in a set of market contexts that we believe are most relevant to today’s IT managers. The models described here discipline and guide the empirical search for IT value by showing that a firm cannot appropriately assess the business value of its IT investments without considering the type of product development the IT supports, the market structure in which the firm competes, and the type of IT in which the firm invests.

**References**

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