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The Productivity Paradox: Is it Resolved? Is There a New One? What Does It All Mean for Managers?

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February 2001

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The Productivity Paradox: Is it Resolved? Is There a New One? What Does It All Mean for Managers?[1]

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Prepared for the CRITO Consortium Industry Advisory Board Panel:
The End of the Productivity Paradox?

The Productivity Paradox: Are We Really Irrational?

Has the productivity paradox been put to rest, and has a new paradox emerged in its place? These questions continue to vex the economics community, including its most powerful member, Federal Reserve chairman Alan Greenspan, and to concern the IT industry, IT users and management researchers.

The whole issue arose over a decade ago, when Nobel Prize winning economist, Robert Solow, famously remarked, "You can see the computer age everywhere but in the productivity statistics." This offhand comment became the Quip that Launched a Thousand Production Functions, as researchers were driven to solve the apparent contradiction to economic theory. For if Solow was right, it meant that businesses were investing billions of dollars on technology with no apparent payoff. Such a massive, widespread phenomenon would certainly call into question the fundamental economic principle that investors and managers are not systematically irrational.

Interestingly, Solow's Quip was based entirely on circumstantial evidence, i.e., the fact that U.S. companies had invested over a trillion dollars in IT the previous decade, but U.S. productivity growth remained well below the rates seen in the earlier post-war period. However, it stimulated other economists such as Martin Baily, Stephen Roach, Gary Loveman and Robert Gordon to conduct more rigorous analyses and they found that the impacts of IT on productivity were not obvious. So the productivity paradox became a thorn in the side of economic theory, a concern for businesses trying to improve profits, and an issue for government policymakers trying to spur productivity and economic growth. If true, it also threatened the IT industry, whose products might be seen as having little economic value in spite of the rapid technological progress that marked the industry.

Resolving the Paradox

The first reaction to the productivity paradox was to try to explain why it might exist. These explanations were summarized by Eric Brynjolfsson (1993) into four categories: (1) measurement errors of IT capital due to rapid price and quality changes, and failure of economic statistics to measure qualitative improvements in the output of service industries; (2) time lags,

[1] This research has been supported by grants from the CISE/IIS/CSS Division of the U.S. National Science Foundation and the NSF Industry/University Cooperative Research Center (CISE/EEC) to the Center for Research on Information Technology and Organizations (CRITO) at the University of California, Irvine. Industry sponsors include: ATL Products/Quantum, the Boeing Company, Canon Information Systems, IBM, Nortel Networks, Conexant, Microsoft, Seagate Technology, Sun Microsystems, Whirlpool Corporation.

an argument made by Paul David (1990), which said that IT would not have a measurable impact on productivity until it reached a critical mass of diffusion and experience; (3) management practices, which had not yet evolved to take advantage of the potential of the technology; and (4) redistribution, i.e., IT might help individual firms relative to competitors, but not increase productivity in the whole economy.

A second reaction was to develop more sophisticated models to tease out the relationship between IT and productivity. Studies in the early 1990s by Brynjolfsson and Loren Hitt (1993), and by Frank Lichtenberg (1993), found evidence that refuted the productivity paradox at the firm level, showing that IT investment was indeed strongly correlated with higher levels of output. At the country level, a study by Kraemer and Dedrick (1994) of Asia-Pacific countries showed a significant relationship between IT spending and GDP growth. These studies were followed by additional studies at the firm and country level, as summarized in Table 1.

Table 1. Summary of IT Payoffs Studies

Study and date	Sample	Findings
CRITO studies		
Kraemer and Dedrick, 1994	12 Asia-Pacific countries, 1984-1990	IT investment positively correlated with GDP and productivity growth
Dewan and Kraemer, 1998 and 2000	36 countries	IT capital positively correlated with labor productivity in developed countries. IT capital shows no significant correlation with productivity in developing countries
Kraemer and Dedrick, 2001	43 countries	Growth in IT investment correlated with productivity growth. Level of IT investment (% of GDP) not correlated with productivity growth.
Melville, 2001	31 industries, 1965-1991	IT returns are positive for US as a whole. Benefit of IT increases with time. Higher IT returns accrue to high growth industries.
Plice, 2001	Six industry sectors for 38 countries	IT capital shows 5-8 times higher ROI than non-IT capital for developed countries
Gurbaxani, Melville and Kraemer, 1998	1694 firms, 1987-1994	Degree to which employees are networked is positively correlated with firm output.
Gilchrist, Gurbaxani and Town, 2001	Panel of Fortune 1000 US firms, 1987-1993	IT productivity is greater in producer firms than in user firms.
Tallon, Kraemer, Gurbaxani, 2000	150 firms, 1998-1999	Greater alignment of IT with business strategy results in greater IT payoffs.
Ramirez, 2001	200+ US firms, 1998	Firm use of employee involvement,TQM and re-engineering enhances IT returns.
Other studies		
Lichtenberg, 1995	US firms 1988-1991	One IS employee can be substituted for six non-IS employees without affecting output.
Hitt & Brynjolfsson, 1997; Brynjolfsson & Hitt, 1997	600+ large US firms, 1987-1994	Firms that adopt IT and decentralized organizations are 5% more productive than those that adopt only one of these
Brynjolfsson and Yang, 1998	Fortune 1000 US firms, 1987-1994	The market value of $1 of IT capital is the same as $10 of other capital stock.
Pohjola, forthcoming	39 countries, 1980-1995	IT investment shows 80% gross returns for OECD countries. No significant returns for developing countries.
Oliner and Sichel, 2000	US, 1991-1995 and 1996-1999	IT capital accounts for about 2/3 of the acceleration in productivity growth after 1995

The studies at the firm level confirmed that IT investment was correlated with better performance, at least for the relatively large companies that were included in most studies. They also show that firms with decentralized organizations performed much better than those with centralized organizations. At the country level, most studies came to the interesting conclusion that wealthier industrialized countries showed a positive and significant relationship between IT and productivity, but that there was no evidence of such a relationship for developing countries. Dewan and Kraemer (1998) hypothesized that this gap was due to the low levels of IT investment relative to GDP in developing countries, and to the lack of necessary infrastructure and experience to support effective use of IT (harking back to David's time lag argument).

The final element of the productivity paradox seemed to be put to rest when the U.S. economy experienced a surge of productivity growth in the late 1990s, nearly returning to the levels of the 1950s and 1960s, and supporting a rate of non-inflationary economic growth that had been considered impossible a few years earlier. The timing of this upswing, coming about 40 years after the introduction of business computers and 20 years after the invention of the PC, supported David's argument for a relatively long time lag between the introduction of a technology and its impact on productivity.

Optimists declared the emergence of a New Economy, in which IT-led productivity (and other factors such as globalization) would lead to a long period of inflation-free prosperity. By the end of 2000, however, the collapse of the technology-led NASDAQ market and a slowing of the U.S. economy brought out pessimists who said that the New Economy was little more than a brief bubble.

The productivity resurgence of the late 1990s raised two new questions: (1) How much of the resurgence could be attributed to IT use? and (2) Are the gains sustainable, or are they a short-term phenomenon? These questions led to new studies that attempt to measure the relative importance of IT in the productivity gains of the late '90s, and to forecast the staying power of those gains. Most of these studies came to optimistic conclusions on both issues, as economists such as Dale Jorgenson and Tim Bresnahan, and even previous skeptics such as Martin Baily and Daniel Sichel came to the conclusion that the gains from IT were real and probably sustainable even through an economic downturn.

The only major dissenter is Robert Gordon, who argues that much of the late '90s gains were cyclical, and that virtually all of the productivity gains in the U.S. economy were concentrated in the durable goods sector, particularly the computer and telecommunications equipment industries. Perhaps most important is the opinion of Greenspan (and Fed economists such as Sichel), who apparently has become convinced that IT-led productivity is real and that the economy can sustain higher non-inflationary growth rates than previously thought.

A New Paradox?

Returning to the various studies on IT and productivity, a new paradox appears to have emerged. It is simultaneously one which vexes IT industry executives and challenges the principles of economics as much as the initial productivity paradox. IT industry executives wonder why business executives do not invest much more in IT than they already do, given that IT returns are

so large and acknowledged by noted economists and distinguished policymakers alike. Overall, IT investment represents about four percent of GDP, has shown a 12% annual increase on average over the last twenty years, and shows no evidence of decline as business executives continue to report that they plan increased investments.

Reinforcing views of the IT industry, and presenting a challenge to economics, is the claim by Brynjolfsson and others (including a new CRITO study by Plice, 2001), that IT investments not only show high returns, but much higher returns than non-IT investments. These studies argue that there is actually a massive *underinvestment* in IT at both the firm and country level. This suggests that managers and investors may still be acting irrationally, in this case by spending too little on IT and thus foregoing highly profitable investments (or leaving $100 bills laying on the floor, to use one author's expression). If true, economic theory is again in trouble, and boards of directors should be sacking management teams en masse for failing to take advantage of such opportunities.

However, we would argue that claims of massive underinvestment in IT should be viewed cautiously. First, the production function models used in most analyses are only models, which are useful but simplified views of the real world. Also, these models show correlation but not causality. Causality could run in either direction (e.g., successful companies or rich countries invest more in IT because they have the resources to do so), or there may be a third factor that is driving both IT spending and productivity growth (e.g., increasing education levels in the work force, or a shift of the economy to more information intensive activities due to financial deregulation). Thus there should be some hesitance to translate the elasticities in a production function into varying rates of return on investment.

Even if one is willing to take that leap, other factors come into play. First of all, the high rates of depreciation for IT investments mean that *net* returns on investment are much lower than gross returns, and taking into account the large standard deviations in the results of many studies, it is possible that the net returns to IT investments are in line with non-IT investments. Second, the risks involved with IT investments may be larger than non-IT investments, due to rapid technology changes, frequent time and cost overruns, and occasional outright failures of IT projects. These risks are keenly felt by managers whose jobs may be at stake in the case of a well-publicized failure.

If, in spite of all of these factors, firms are still underinvesting in IT, it might be due to the very difficulty of forecasting and measuring the returns on such investments. Few firms that we have interviewed have put in place the means to monitor the returns on specific projects or investments. An Economist Intelligence Unit (1999) survey indicated that only about 50% of business executives use some kind of ROI evaluation for IT projects. Even fewer evaluate projects after implementation. In the absence of measures of IT returns, IT spending is often treated as a budget item rather than an investment, and capped at some percentage of total revenues. Another factor could be the shortage of IT professionals, which might make it impossible to carry out all of the projects with potentially positive returns. Labor market rigidities and lag times in educational choices can leave skills shortages in place for years (or even decades in some countries).

Finally, it is possible for firms to be investing at an optimal level in IT but still to have underinvestment at the national level. This is because the social returns on investment might be greater than the private returns, as is the case with education and R&D. Brynjolfsson (1995) argues precisely this when he says that IT creates a consumer surplus. If this is the case, there may be an argument for governments to promote IT use through measures such as training programs, accelerated depreciation rates, tax policies that treat software spending as an investment (as the U.S. now does), and liberalization of telecommunications markets to lower the cost of Internet access.

What are the implications for managers?

How should executives and managers view the results of these studies as they make their own decisions about IT investments and related management decisions? We recommend the following considerations:

- The original productivity paradox has been resolved. On average IT spending does pay off, and there is no need to fear that technology investments are a systematic waste of scarce resources. Rather, managers should be concerned with whether their own IT investments are paying off, and what they can do to maximize the returns on those investments.

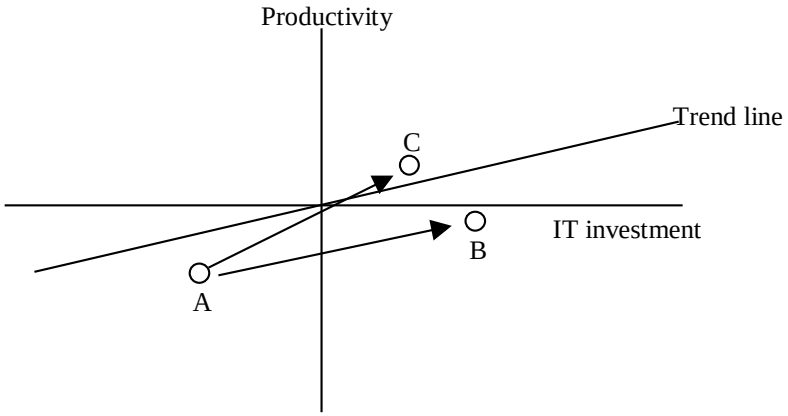
- As for the new paradox, in spite of the optimistic findings about the high returns on IT investments, managers cannot simply give $1 to their favorite IT vendors and expect to get $2 in return. First, the results are an average and not a guarantee of any company's likely return. Second, as many of the studies point out, the most important variables are organizational structure and management practices. In fact, a study by Brynjolfsson and Hitt (1998) found that companies who invest heavily in IT within centralized organizations perform worst of all. Our own studies found that management practices such as IT alignment with business strategy, employee involvement, total quality management and re-engineering, enhance IT returns (Tallon, Kraemer and Gurbaxani, 2000; Ramirez, 2001). At the case study level, we can compare Dell Computer, which has been very successful investing in IT to refine and extend its well-designed direct business model, to Compaq, which invested heavily in an SAP implementation to improve the performance of its complex indirect business model, with poor results.[2]

- So the biggest concern for managers should be restructuring their organizations and implementing effective management practices. In such an environment, IT investments are likely to be most productive. Figure 1 is a stylized graph which illustrates the relationship between IT investment and productivity, and two ways in which a firm might increase productivity. The trend line shows the average relationship for a large number of firms, as seen in some of the firm level studies in Table 1. But suppose a firm is at point A, meaning it is spending a relatively low share of revenues on IT, and is also below the trend line, meaning it is getting a below average return on its IT investment (probably due to poor management practices). If that firm increases its IT investment without changing its management practices, it is likely to move parallel to the trend line to point B, an expensive way to make modest gains in productivity. On the other hand, if it increases IT spending

[2] For Dell, see Kraemer et al., 2000. For Compaq, see Dedrick and Kraemer, 1999.

(even to a lesser extent), while making corresponding changes in its structure and processes, it could move to point C—a greater gain at a lower cost. As several interviewees put it, "The key is getting the business processes right. Then the IT might be simple or complex, and the investment small or large, but the payoff will be there in any case because of the joint investment."

Figure 1. Two paths for improving productivity with IT



- Research points to several managerial practices that are shown to complement IT investments and improve firm performance. Based on our surveys and case studies, and the work of others, we would identify the following lessons for managers:

  - Aligning IT investments with business strategy is critical to success. This has been stated often in the management and IS literature, yet large numbers of firms still suffer from poor alignment of IT and business objectives. A key to achieving alignment is greater interaction between business executives and IT executives—involving IS executives in business planning on the one hand and involving business executives more in IS planning and investment decision making on the other hand (Tallon, 2000).

  - Decentralized organizations are more successful overall, and show better returns on IT investments. The model associated with many successful high-tech companies is the "virtual company," which is decentralized internally and has strong links to external suppliers, customers and business partners. This model allows for flexibility and responsiveness in dynamic markets, and allows firms to focus their attention on core, strategic functions, while leveraging the capabilities of business partners for other activities. IT and e-commerce play a vital role in coordinating the internal and external relationships in such a model.

  - Decentralized IT organizations, coordinated by a strong CIO, appear to be effective in many cases. Two well-known case studies of successful IT use are Dell Computer and Cisco Systems. Each has a strong CIO who is responsible for setting architectural and infrastructure standards, and designating certain application standards across the company. But IT projects are largely staffed and funded within functional departments, which have leeway in determining their own spending

priorities and choosing applications relevant to their own operations. Compaq, which formerly was highly centralized, has since moved more responsibility and staffing to individual business units, partly in response to complaints about the centralized, top-down approach taken to the SAP implementation.

- IT is most effective when implemented in conjunction with complementary practices such as total quality management and process redesign. This is the finding of survey research and is reinforced by case studies. For instance, Apple Computer attempted to introduce SAP into a dysfunctional business environment in the mid-1990s, and ended up abandoning the effort. In 1997, Apple jettisoned several product lines and reorganized into a simpler structure, then began implementing SAP with much better results (both in terms of the implementation itself, and performance measures such as inventory turnover).

- Benchmark against other companies to understand where you are in terms of IT investment and performance measures. Most companies have no idea how they rank in relation to their peers and competitors in variables such as IT spending levels, structure of IT costs (e.g. hardware, software, outside services), or perceptions of IT effectiveness on the part of IT managers and other executives. Participating in benchmark studies such as those conducted by CRITO and various research firms can provide baseline data for measuring the effectiveness of IT.

- Develop internal methods to measure returns on IT projects, and to learn from successes and failures in order to reduce risk and improve performance in the future. Such metrics need to be developed by teams that include IT managers and managers of functional units so that they measure outcomes that are most important to business strategies (one aspect of alignment). Measuring the impacts of IT on broad performance variables such as revenue per employee or return on assets is very difficult, so there is a need to develop process-oriented variables that can be translated into dollars and cents impacts. For instance, inventory turnover improvements can be directly attributed to IT investments and related process changes. It should then be possible to translate such an improvement into a measure of cost savings if the cost of carrying inventory can be estimated.

  As projects are completed, it is valuable to gather feedback from IT staff and others involved as to what problems were faced, how they were solved, and what impact the new systems had on specific operations. This information can be documented and made available through knowledge management systems for others in the company to use. There should also be mechanisms in place for people to interact with others outside their usual work groups and share practical information and experience. Such development of institutional knowledge can enhance IT performance and also help better align the IT function with overall business strategy.

What are the implications for the IT industry?

- Celebrate. The IT industry's products and services do improve customers' productivity, and the resolution of the productivity paradox should encourage IT users to continue to invest. Quietly counter the naysayers (who seem to attract media attention) by seeing that positive results get attention.

- Promote education and learning about the organizational and management practices that enhance the returns from IT investments and decrease the likelihood of failed investments. Realizing returns from IT investments is not a simple matter. It requires appropriate infrastructure, human capabilities and organizational learning. Employing what is known about successful management practices will help to ensure smart investments.

- Tone down the marketing rhetoric that creates unrealistic expectations about IT returns. The IT industry is notorious for hyping every minor innovation as "revolutionary" and for making extravagant claims about the capabilities of its products. Such rhetoric confuses customers and IT professionals alike. More importantly, it sets customers up for disappointment if a product turns out to be simply useful, and leads to skepticism on the part of users. IT companies would do well to heed the admonition "under promise and over deliver."

- Be a model of success for your customers. Show them how you use your own technology to improve your performance. Most economists do not agree with Robert Gordon that nearly all of the productivity gains of the past few years can be attributed to the IT industry itself, but there is no doubt that the IT industry has shown exceptional productivity gains and is a heavy user of IT itself. Companies such as Dell, Oracle, and Cisco promote themselves as models of how to use IT and the Internet effectively. This not only helps sell products, but it puts the whole company on alert that others are watching, so the company must be a model of effective IT use.

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