
# The Info-Tech "Productivity Paradox" Dissected and Tested

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**Investments in IT will show zero productivity when there is poor use of organizational resources, according to a new study.**

Researchers who have examined the effect of information technology (IT) on productivity have found little or no relationship at the economy-wide, industry-wide, or firm level. In other words, there has been a "productivity paradox," and this has been one of the most heavily researched information systems topics in the last 20 years. We test a new explanation for the productivity paradox at the firm level: Does implementing IT cause organizational slack? Our empirical evidence shows that increased organizational slack was an explanation for the productivity paradox before 1991 but not after.

## Why a Productivity Paradox?

Since the dawn of the IT revolution, significant investments in IT have often been justified in terms of their potential to increase productivity. This initial euphoria, however, was quickly replaced with skepticism because hard evidence of productivity gains from IT failed to materialize. Economists generally were puzzled by the fact that, in spite of the significant increase in IT investments, the U.S. output was not growing any faster, and IT did not seem to have any effect on the post-1973 slowdown of labor productivity.[1] Nothing captures this sentiment better than a statement by the Nobel laureate economist Robert Solow: "We see the computer age everywhere except in the productivity statistics."[2]

Firm-level evidence of the impact of IT was equally disappointing. While IT investments in the service sector had increased significantly, the productivity of white collar workers decreased by more than 6% from the mid-1970s to the mid-1980s. The first empirical research of the productivity paradox, completed in 1988, showed that companies were better off investing their marginal dollars in non-IT factors of production.[3] Results from IT consultants were equally disappointing. They found no correlation between expenditures on IT and profitability, claiming that this relation has not changed in more than 20 years.[4]

The early literature that tried to explain the reasons for the productivity paradox suggested numerous theories. These explanations were subsequently validated in the 1990s by a series of empirical studies. Academic scholars have proposed several explanations for the paradox.[5] First are the explanations why there is no real gain in productivity or performance from IT investments: mismanagement of information and technology

and redistribution and dissipation of profits.

At present there are two possible interpretations for mismanagement of information and technology. Managers may have a hard time bringing the benefits to the bottom line, especially if investment in IT is not accompanied by changes in business processes. "Successful IT implementation processes must not simply overlay new technology on old processes."[6] The result is that investments in IT lead to increases in organizational slack rather than productivity and improved financial performance. Second, managing IT projects is inherently difficult, and a high percentage of IT projects encounter significant problems such as cost overruns, coordination problems, or failure during implementation.[7] Several researchers suggest that another possible explanation is the redistribution or dissipation of profits.[8] For example: "IT rearranges the shares of the pie" in favor of some companies "without making it any bigger."[9]

The second set of reasons for the productivity paradox involves a gain in productivity or performance from IT that researchers have not properly identified or measured. The gains do not show up because of mismeasurement of inputs and outputs, delays in productivity due to users learning about and adjusting to new technologies, and "capital stock theory."

Several authors have attributed the productivity paradox to mismeasurement.[10] For example, one researcher linked the potential mismeasurement of IT-related inputs and outputs to the difficulty of developing accurate, quality-adjusted price deflators that would determine the real cost of computers.[11] Because of the rapid change in technology capability and capacity and the cost of technology, comparing technology assets purchased at different points in time is inherently difficult. It also is difficult to determine the real cost of computers by comparing costs to what they were in previous years because the current generation of computers is not directly comparable to computers purchased in previous years.

Another author argues that, with more than 70% of the IT investment in the service sector, where output is not well measured, it is not surprising that IT investment has not translated into measurably higher productivity.[12]

Lags due to employees needing to learn and adjust to new technologies also are a possibility for the productivity paradox, as is possible organizational restructuring that new IT causes.[13] In fact, it may take several years before the benefits associated with investments in IT materialize.

Finally, so-called capital stock theory argues that in spite of the recent spending on IT, its share of capital stock is still small. The reason: Firms have only recently started investing heavily in IT, and IT tends to become obsolete rapidly, making it difficult for researchers to directly observe the impact of investment in IT on financial performance.

In all likelihood, the productivity paradox is due to a combination of factors. In order to better understand it, each proposed explanation should be tested independently and together.[14]

## Empirical Research

Most of the proposed explanations for the productivity paradox have been tested empirically. As we noted above, there are two possible interpretations of mismanagement as an explanation. First, to what extent have companies been recognized by industry experts and peers as successful users of IT? Do these firms experience a significant performance advantage relative to their competitors? Their empirical results support the argument that successful investment in IT leads to superior financial performance.[15] On one hand, mismanagement was empirically tested and validated as an explanation for the productivity paradox.[16] But on the other hand, another researcher theorized that increased slack has not yet been empirically tested.[17]

Redistribution has been tested in two studies.[18] One, by Paul Belleflamme, used the recent proliferation of e-commerce to support the redistribution argument. Consider an oligopolistic market with all firms investing in IT to differentiate their products and services. This results in excessive total IT investment from an industry perspective, and, despite product differentiation, most e-commerce companies are not yet profitable. For many of them, a Web presence has only increased their cost. The other study, by Timothy Bresnahan, Paul Milgrom, and Jonathan Paul, examined the role of improved information in the stock market and found that

improved information did not contribute to productivity increases because the information only affected those who received the gains; it did not increase the overall social gain from stock market activity.

The possibility of the productivity paradox as a measurement problem was considered and empirically tested.[19] This research calculated the contribution of input such as capital invested in staff labor for computer and information systems (IS) versus their output. Output was measured in inflation-adjusted dollars because this partially accounts for changes in product quality and the introduction of new products. The results indicated that IS made a substantial and statistically significant contribution to firm output and that the productivity paradox disappeared by 1991.

Several studies have tested and validated the proposition that it takes several years before the results of IT investments show up in organizational performance.[20] Their conclusion was that IT investments eventually do pay off for the investing companies. Still further, testing the capital stock explanation for the productivity paradox showed that computer equipment accounted for only 2% of all the physical capital stock, and the contribution of computer equipment to output growth was insignificant.[21]

Even the productivity paradox at the economy-wide level was refuted with studies in the late 1990s. For example, during the economic expansion of the 1990s, the prior decline in labor productivity reversed. The turnaround at the economy-wide level came in 1995 when U.S. output began rising by 2% annually. Researchers observed that after almost 25 years of decline, labor productivity rebounded in the second half of the 1990s.[22] Using the same framework as in their earlier work, Stephen Oliner and Daniel Sichel found that IT accounted for about two-thirds of the increase in productivity growth between the first and second half of the 1990s.

Still, the paradox may not have been resolved completely. From Sichel comes the following: "Although [increased productivity] could represent a break from the past, the large gains of the past few years may turn out to be a transitory response to unusual rapid declines in computer prices and a very robust economic environment."[23]

So our review here of empirical literature leads us to two propositions that warrant further testing. The first is the untested proposition that investment in IT increases organizational "slack" but not output or profits. The second is the notion that the productivity paradox was a function of the 1980s and disappeared by the early 1990s. It has been argued that additional, complementary investments have been required in other intangible assets such as worker knowledge, new organizational structures, process redesign, or interorganizational relationships to fully realize the benefits of IT investments. As such, there should be an adjustment time required to match IT investments and the organizational factors that all appear to be important in realizing the maximum benefit of IT. In the 1980s, these complementary investments had not yet been made. We will expound upon these ideas and offer testable hypotheses. But first we discuss organizational slack and how it relates to IT.

## Organizational Slack

What is "organizational slack," and why is it important?

Organizational slack has been defined as the difference between the maximum and the optimum utilization of available resources.[24] Slack can also be thought of as the degrees of freedom in a company that easily allow it to absorb change in its competitive environment.[25] It could be as simple as adding an extra assistant to a department or allowing managers to spend less time performing routine tasks and more time making key organizational decisions. Slack also can appear in the way a company treats its employees. For example, instead of overworking them, a company with slack allows its employees room to breathe, increase efficiency and effectiveness, and literally reinvent themselves. Other examples of slack include wages and benefits in excess of what is required to retain employees and executives, loss of profitability by uncontrolled subunit growth, and staffing in excess of what is needed to sustain average production rates.

Organizational slack can have either a positive or negative effect on an organization—positive when the proper amount of slack promotes innovation by intra-organizational competition and negative when too much slack actually reduces innovation.[26]

Companies don't create slack consciously.[27] That is, they tend to build slack resources during good times and reduce slack resources during bad times. This is certainly true with IT. When IT is considered a panacea, nobody questions IT investments. Nor are there rigorous criteria for return on IT investment (ROI). Instead, there's just more funding available for IT, and anything related to IT tends to have a soft budget. But when people start questioning IT's ability to deliver, then the spending begins to be accounted for in terms of its ROI. Only then is IT-related slack reduced.

Sufficient slack resources can help protect a firm from sudden changes in its external environment by holding some resources in reserve that can be deployed as needed.[28] Firms investing in sufficient slack resources generally exhibit improved company performance, whereas those with insufficient slack resources tend to exhibit lower performance.[29] They are more likely to encounter managerial rigidity or even managerial paralysis when the need for change is critical, as it is in times of reorganization. For example, if managerial rigidity occurs, shareholder value might be dissipated because management might not make timely decisions needed to halt a downward spiral of company performance.

Slack resources can facilitate both risk taking and innovation. Slack is a resource in excess of what is required for the normal operation of an organization. As slack is generated, the organization can afford to experiment with new strategies and innovations only because slack can act as a buffer that helps the company maintain stability when facing adverse business situations. Therefore, slack can encourage managers to take risks because it allows an organization the ability to absorb costs associated with failure.

Slack resources also are able to help a firm bear the costs of innovation and to explore new ideas in advance of actual need. Organizations with appropriate slack resources can afford more sophisticated information search activities, such as an integrated accounting information system.

How is slack measured? There is a great deal of existing research that emphasizes the financial measures of organizational slack. Slack resources can be separated into three categories by evaluating the degree to which the resources are easily recoverable. From most to least easily recoverable, the three categories are (1) available, (2) recoverable, and (3) potential.[30] Available slack can be measured by the ratio of current assets/current liabilities, which indicates a firm's ability to accumulate more short-term liabilities.[31] Recoverable slack can be measured by ratios such as accounts receivable/sales, inventory/sales, and SG&A/sales.[32] The ratios of accounts receivable/sales and inventory/sales measure are the two largest noncash components of working capital as a percentage of sales. These capture short-term slack, the ability to meet changes in demand, short-term cash-flow needs, and the like. SG&A expenses as a percentage of sales are the excess expenses built into the firm's cost structure that could be recovered when needed. Finally, potential slack can be measured using the interest coverage ratio, which indicates the firm's ability to take on additional long-term debt. Potential slack has been measured using debt-to-equity ratios and price-to-earnings ratios.[33]

### Our Hypotheses and Theory

The year 1991 has been presented as the end of the productivity paradox era.[34] Other researchers agree, indirectly saying that there was no stock-market reaction to IT investment announcements during the productivity paradox era of 1981-1990 but that they do find a significant positive market reaction to IT investment announcements after the productivity paradox era of 1991-1996.[35] Our first hypothesis, therefore, is that the increase in slack after implementing IT occurred before the end of the productivity paradox era in 1991:

> **Hypothesis One (H1):** There will be an increase in slack for firms that implemented IT during the productivity paradox era but not after.

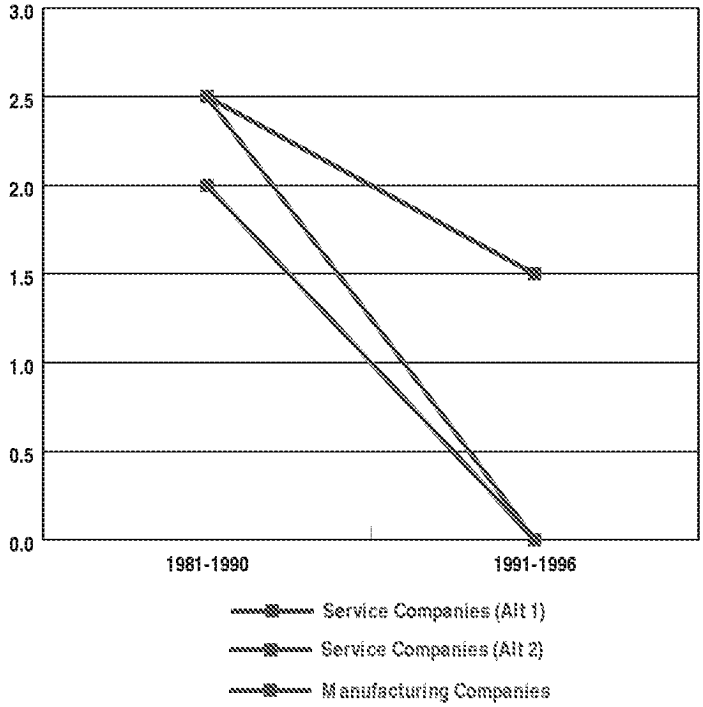
Service companies did not initially change their way of doing business to be more efficient because there was not much international competitive pressure.[36] Accordingly, investment in IT by service companies did not improve their productivity and made them less profitable. Therefore, we expect that service companies will realize a larger increase in slack after implementing

IT than will manufacturing companies. This leads to our second hypothesis:

**Hypothesis Two (H2):** The increase in slack for service firms from IT implementation is more than that for manufacturing firms.

In Figure 1 we show our expectation that manufacturing and service firms had increased slack during the productivity paradox era, pre-1991, but that service firms had a larger increase in slack than manufacturing ones. In the post-productivity paradox era, we were unsure if there were still a difference between service and manufacturing firms or if companies increased slack at all after implementing IT. This is shown in Figure 1 as two alternative scenarios for service companies and one scenario for manufacturing companies.

## Figure 1: Hypothesized Change in the Mean Level of Organizational Slack.




### Methodology

To test our hypotheses, we studied IT investment announcements that firms made from 1981 to 1996.[37] We were interested in the amount of organizational slack stemming from the IT investment compared to the level of slack before it. Organizational slack is measured as the sum of three financial ratios: accounts receivable as a percentage of sales; inventory as a percentage of sales; and selling, general, and administrative expenses as a percentage of sales. We measured the change in slack by taking the average of it for five years after the IT investment announcement and subtracting the average level of slack for the five years before the investment. To control for industry-wide changes in slack, we standardized each of our slack measures by the industry level of slack in each year. That way, if overall slack decreased in an industry—for example, due to competitive pressures—the industry-wide change in slack would not be attributed to the IT investment of a company we studied. We also used two other variables, size and performance, to control for changes in slack not attributable to the IT investment. Performance was measured as the level of return on equity above or below the industry average (ABROE) and firm size by the natural log of net sales. In Table 1 we offer descriptive statistics for our variables. As the table shows, the change in organizational slack increased significantly following the investment in IT.

## Table 1: Descriptive Statistics

| Variable | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| ΔSLACK | 109 | -3.93 | 11.38 | 0.57 | 1.97 |
| SIZE | 109 | 4.28 | 11.86 | 9.00 | 1.52 |
| ABROE | 109 | -130.85 | 94.70 | 7.21 | 22.29 |

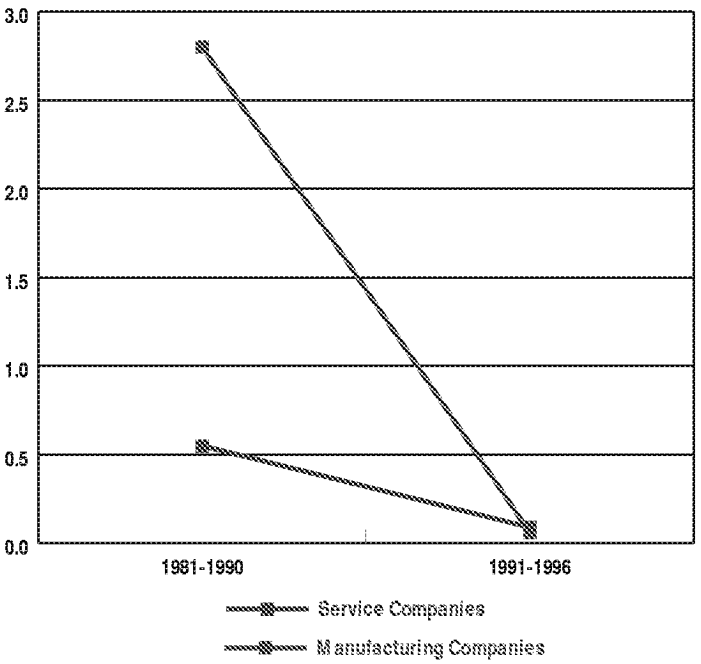
Where:

ΔSLACK = The change in the relative level of organizational slack due to IT investments, measured as slack after IT implementation minus slack before IT implementation.

SIZE = Firm size, measured as the natural log of net sales.

ABROE = Abnormal return on equity, measured as ROE minus the industry median ROE.

## Figure 2: Change in the Mean Level of Organizational Slack.




## Table 2: Regression Analysis

$\Delta SLACK = b_0 + b_1 SIZE + b_2 ABROE + b_3 TIME + b_4 INDUSTRY + b_5 TIME \times INDUSTRY + e$

| Variable | Coefficient | Predicted Sign | Parameter Estimate | t | Significance* |
|---|---|---|---|---|---|
| INTERCEPT | $b_0$ | | 1.113 | 0.910 | .365 |
| SIZE | $b_1$ | | 0.192 | 1.683 | .095 |
| ABROE | $b_2$ | | -0.006 | -0.812 | .418 |
| TIME | $b_3$ | H1: – | -2.706 | -4.622 | **.000** |
| INDUSTRY | $b_4$ | H2: + | -2.254 | -3.735 | **.000** |
| TIME x INDUSTRY | $b_5$ | | 2.236 | 2.995 | **.003** |

**Adjusted R Square** = .250 **Number of Observations** = 109

* p-values are for two-tailed tests. Values in bold are significant at p<.05.

Where:

- $\Delta SLACK$ = The change in the relative level of organizational slack due to IT investments, measured as slack after IT implementation minus slack before IT implementation.
- SIZE = Firm size, measured as the natural log of sales.
- ABROE = Abnormal return on equity, measured as ROE minus the industry median ROE.
- TIME = A time period dummy variable, zero in 1981-1990 and one in 1991-1996.
- INDUSTRY = A dummy variable representing service (one) or manufacturing companies (zero).
- TIME x INDUSTRY = Interaction term between the TIME dummy variable and the SERVICE dummy variable.

### Results

To arrive at our results, we first looked at the average change in slack around IT investments made by four groups: service companies from 1981-1990, manufacturing companies from 1981-1990, service companies from 1991-1996, and manufacturing companies from 1991-1996. We graphically show the results of these tests in Figure 2.

The mean slack increased by 0.55 for service companies in the period 1981-1990, which is not significantly different from zero. Mean slack increased by 2.80 for manufacturing companies in the period 1981-1990, which is significantly different from zero at p<.01. In the 1991-1996 period, slack increased 0.09 for service companies and 0.05 for manufacturing companies, neither significantly different from zero. It appears from these results that our first hypothesis is supported, that slack increased significantly after implementing IT during the productivity paradox era—before 1991—but not after. Our second hypothesis, however, is not supported. Just the opposite of what we expected: Manufacturing companies had a significant increase in slack after implementing IT, and service companies saw very little change in slack after implementing IT.

We used regression analysis to test if the differences between service companies and manufacturing companies were statistically significant and if the difference before and after 1991 was statistically significant. As shown in Table 2, the differences between manufactur-

ing and service companies and the two time periods are significantly different from zero at p=.000.

The third significant variable in our regression analysis was the variable represented by the interaction between the time and industry dummy variables. Interpreting this variable was somewhat difficult. Manufacturing companies saw a large increase in slack after implementing IT in the productivity paradox era and no significant change in the post-productivity paradox era. Service companies did not have a large increase in slack in either period. The interaction variable between time and industry is testing whether the change over time in the increase in slack for manufacturing companies is significantly different from the change service companies experienced. Another way to look at it is that this variable is testing whether the slopes of the two lines in Figure 2 are different. As expected, the difference is statistically significant.

### Future Technology Investments

The productivity paradox has refused to go away despite research showing that IT, when used effectively, can—and does—improve performance. Our research shows that IT investments in the 1980s were not particularly beneficial for manufacturing firms. This was probably due to the overlay of technology on existing processes that created slack rather than using IT to streamline and improve operations. This would explain the early research regarding the lack of productivity gains and performance improvements following investment in IT prior to 1991 and why more recent research has shown the productivity paradox disappearing in the 1990s. Our research leads us to agree with claims that "the productivity paradox disappeared by 1991."[38]

Our results have implications for people managing IT investments. For example, the business benefits of yet another technological breakthrough, radio frequency identification tags, or "smart tags," have the potential to shrink inventories by 5% to 25%.[39] If this prediction is correct, then "...the increase in efficiency of inventory management during the past two decades, thanks to 'just-in-time,' 'Dell-ization,' and so forth, will take another huge leap forward, helping to keep America's recent productivity miracle going—and, with luck, spreading it to the rest of the world."[40]

On a regular basis, IT and non-IT managers are bombarded with information about a new "killer application" or technology that has the potential for substantial cost savings that will propel the company's competitive advantage. One key characteristic of a good manager is the ability to sort through the hype to find the right type of IT investments that have the potential to generate the desired results. But this decision is not an end unto itself. As we have seen with the productivity paradox, investments that start with the best intentions may not deliver the desired results. What we have seen in this study is that this is likely to happen if the IT investment leads to increased slack rather than improved efficiency or profits.

There are three reasons why we think that this may happen, and all managers should become aware of these risks. One, there is no technological solution that will cure all of your business maladies, but history has shown that certain technologies, when exploited within the context of a company's resources and capabilities, do have the potential to generate above-normal profits. Two, failure to recognize that there is no cure-all can lead to slack. This happens when a group or department within a company is assigned to deliver and manage the IT "panacea" with an elastic budget. Requests for additional funding or resources tend to be less scrutinized. Before you know it, the department has absorbed a significant amount of unrecoverable organizational slack. Three, there is the risk that both upper management and the team responsible for implementing IT investments as a panacea will not think carefully about the proper implementation. After all, it is supposed to be a panacea, so why bother? Investment in new technology delivers its full potential only when it is properly implemented and integrated into existing or redesigned processes. Failure to do so simply adds another layer of cost with benefits that are smaller than expected. ■

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