Solving the Productivity Paradox: the Mysterious Link Between Computers and Productivity

Consider the following development. Between 1992 and 1995, investment in office computers in the Canadian service sector rose 64.2 per cent in real terms, but total factor productivity advanced a meager 1.2 per cent. Even more perplexing as Figure 1 shows, the service industries with the highest proportion of computer investment in total investment tended to experience the worst total factor productivity growth! Was not the explosion of computer power supposed to increase productivity growth? What accounts for this paradoxical behaviour of productivity growth, a development economists have labeled the "productivity paradox"?

There are no shortage of explanations for this development. At a recent international conference on the issue organized by the Ottawa-based Centre for the Study of Living Standards (papers are available at www.csls.ca), expert opinion was solidly divided. Three basic hypotheses were advanced. Some argued that the benefits of information technology (IT) are already here, but are just not being captured by the statistical system. Others said to have patience, pointing out that there are inevitable lags associated with the emergence of the benefits of IT and these benefits are just around the corner. Still other believed that IT has been vastly oversold as a source of productivity improvement.

<u>the mismeasurement hypothesis or “the benefits of IT are already here”</u>

The obvious starting point for any attempt to unravel the mysterious relationship between computers or information technology (the two terms will be used interchangeably) and productivity lies in the area of measurement, or more accurately mismeasurement. The case that the benefits of computers are already here, but are just not being captured correctly has a certain intuitive appeal. Three strands can be identified to this argument. First, for a number of reasons, statistical agencies may be underestimating increases in real or inflation-adjusted output (and hence productivity) arising from computerization, particularly in the service sector.

A comparison of the banking and telecommunications industries sheds light on this output measurement issue. Both industries have made significant IT investments. The number of transactions per worker in both industries has increased tremendously. Output in the telecommunications industry is defined on the basis of the number of transactions (e.g. number of calls). Output in banking, on the other hand, is defined on the basis of the margin between the interest charged for loans and paid for deposits, not the number of cheques processed. Not surprisingly, productivity growth in telecommunication carriers has skyrocketed, with output per worker increasing 6 per cent per year in the 1990s, while that in banking has been very weak (less than 1 per cent per year). A switch to measuring banking output on a transactions basis would solve at least some of the productivity paradox. The public sector is another area where a transactions-based approach to output measurement would likely reveal much greater productivity gains than those recorded in the productivity statistics.

A second strand of the mismeasurement hypothesis argues many of the benefits of IT by their very nature cannot be captured in output statistics. Examples of these types of benefits include greater customer service such as the convenience of 24 hour world-wide banking through ATMs, greater access to information through the world wide web, faster and cheaper communications through e-mail, and higher job satisfaction arising from the use of IT. According to this view, if these benefits were properly quantified, the societal welfare would be much greater that implied by our national income statistics.

There is undoubtedly truth in this. But the same argument can be made that in the past we did not fully capture the societal benefits of new goods and services as well as quality improvements in existing products. Earlier technological innovations increased productivity growth and economic welfare even without the inclusion of non-quantifiable benefits. Why cannot IT do the same?

A related argument sees IT as a strategic tool that can be used to create a competitive advantage for a firm. From this perspective, IT is introduced not to increase the size of the overall pie through productivity improvement, but to increase a particular firm's share of the pie. From the firm's point of view, the benefits of IT can be very large if IT results in an increase in market share. But from the point of view of the overall economy and society, without productivity increases, the benefits of IT are zero.

A third and final strand of the measurement issue argues that IT has in fact increased the trend or underlying productivity growth. But this favourable development has been masked by negative influences on productivity such as slow demand growth. The evidence for this position appears weak.

<u>the lag hypothesis or "the benefits of IT are coming"</u>

The second major hypothesis advanced to explain the productivity paradox argues that IT has enormous potential to increase productivity, but certain barriers prevent the realization of this potential. Once these barriers are removed, productivity gains from IT will be substantial. To support this view of long lags in the effective implementation of new technologies, an historical analogy is often made between IT and electricity. Apparently, the slow diffusion of electricity resulted in faster productivity growth only in the1920s, 40 years after the first dynamos were introduced. As a counter argument, it is pointed out that the very large decrease in the price of computers has made their diffusion much more rapid than that of electricity, and hence reduced the basis for a lagged productivity effect.

Organizational structures poorly suited to the effective implementation of IT have been identified as one possible barrier. For example, existing organizational hierarchies and rigidities may prevent any productivity gains arising from IT at the individual level from showing up at the level of the organization. With greater access to information and means of communication provided by IT, decentralized, flatter organizational structures that give employees more control over the work process may be needed to translate the productivity-augmenting potential of IT into reality.

The effective use of IT requires a workforce able to harness IT's potential. Thus, a poorly trained workforce may constitute a second barrier to productivity improvement.

The failure of many organizations to provide their employees with sufficient and appropriate IT-related training may account for the lack of productivity improvement arising from the introduction of IT.

A third barrier to effective IT use lies in usability problems that plague computers. Lack of standardization and excessive complexity often reduce the effectiveness of software programs. Without user-friendliness, the productivity-enhancing potential of IT cannot be realized.

The proponents of the lag hypothesis argue that the barriers outlined above are coming down. Organizations are becoming more flexible, the workforce is increasingly computer literate, and computer programs are becoming more user friendly. This means that the conditions necessary for the effective use of IT may soon be in place, with improved productivity growth on the horizon.

the exaggerated IT benefits hypothesis or "the benefits of IT are never coming"

The third hypothesis to explain the productivity paradox is that the ability of IT to raise economy-wide productivity has been exaggerated. From this perspective, there is no productivity paradox as IT should not have been expected to result in substantial productivity improvement in the first place.

This inability of IT to raise productivity growth is based on a number of factors. First, despite its prominence in discussions of investment, IT represents only a small share of total investment in the economy. As Figure 2 shows, in 1996 business investment in office machines, valued at $6.9 billion, accounted for only 9.6 per cent of current dollar total investment. As the contribution of an input to output and productivity growth is believed proportional to its share in output, IT's small investment share suggests one should not expect any major impact on productivity.

As a counter argument, it is pointed out with declining computer prices, the constant dollar share of IT in total investment (29.5 per cent in 1996) greatly exceeds the current dollar share, suggesting a greater potential contribution to productivity. Equally, in certain sectors such as business services, trade, and finance, insurance and real estate (Table 1), IT represents a large share of current dollar total investment, and an even larger share of constant dollar investment. Yet, productivity growth in these sectors has been weak, suggesting that a paradox does exist..

A second and more fundamental reason why IT may have failed to revive productivity growth is that in many areas IT does not fundamentally alter the production process and improve productivity. For certain tasks and activities, IT indisputably raises productivity. But for many white collar and service activities it is not obvious that IT fundamentally changes the nature of the production process in a manner that increases productivity. Certain computer applications such as spread sheets, graphics and presentation programs, E-mail, and web sites may create little value, while others such as computer games like solitaire may actually be productivity sinks and reduce productivity. Equally, it is hard to make the case that computerization increases the quality of decision-making. The equation of the silicon chip with the great innovations of the past, like the stream engine, the internal combustion engine, the railway, and

electricity, may be misleading. Many workplace activities may just not be amenable to productivity improvement through computerization.

A third factor behind the exaggerated IT benefits hypothesis is that the costs associated with the operation of computer systems are greatly underestimated, and these costs significantly reduce the net benefits of IT. These costs include hardware and software upgrading, technical support for computer systems, employee training and retraining, and the substitution of expensive labour and machines for cheap labour (e.g. highly-paid professionals using powerful computers to produce fancy overheads). Probably the best known example of the underestimated costs of computers is the year 2000 conversion problem, which according to one estimate, will cost $600 billion US worldwide to correct. While some argue these costs are transitional, others see them as of a permanent feature of the use of IT.

A Summing Up of the Arguments

As is the case with most economic puzzles, there is no one solution to the productivity paradox. Rather the hypotheses discussed above may all be capturing different aspects of the productivity paradox and contribute to the explanation. But in my view, a stronger case can be made for the relevance of the mismeasurement and exaggerated benefit hypotheses over the lagged benefit hypothesis.

For many tasks and activities, computers are a boon for productivity. They reduce human toil. Based on quantifiable indicators of output such as transactions processed, studies show that the introduction of computers into many sectors, such as telecommunications, banking, and public administration has, increased productivity. When these performance indicators are the basis of the output measure used to calculate productivity, as in telecommunications, the statistics show significant productivity gains. When they are not, as in banking and public administration, productivity is stagnant. Thus output mismeasurement is an important part of the productivity paradox.

But for many other task and activities, computers have limited potential to raise productivity as they do fundamentally affect the nature of the production process. This is the case for many managerial and professional activities. The introduction of computers in these areas, while undoubtedly producing non-quantifiable benefits, does not directly increase any quantifiable indicator of output. Thus, in many areas, the potential for productivity gains from computers has been oversold, creating the allusion of a greater productivity paradox than actually exists.

The lagged benefits hypothesis explains less of the productivity paradox than the other two hypotheses. The main reason is that computers are now widely diffused. It is difficult to believe that barriers to their effective use have not yet been largely overcome, if they ever are to be overcome. A possible exception may be the role inappropriate organizational structures play in the failure of firms to realize potential IT benefits, but this factor’s contribution to the productivity paradox is probably small.

Implications of the Findings

The analysis of the productivity paradox presented above has important implications for both government and business. From the point of view of public policy, the finding that output mismeasurement is an important part of the explanation of the productivity paradox suggests that a key priority must be the development of better output and performance measures and indicators, particularly for the service sector (including public administration) where measurement problems are the most severe.

From the point of view of the private sector, the finding that much of the productivity paradox has been based on an exaggeration or overselling of productivity gains from computerization should lead, in cases where the productivity effects of IT are not easily quantifiable, to tougher approval criteria for IT investment decisions.

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Table 1

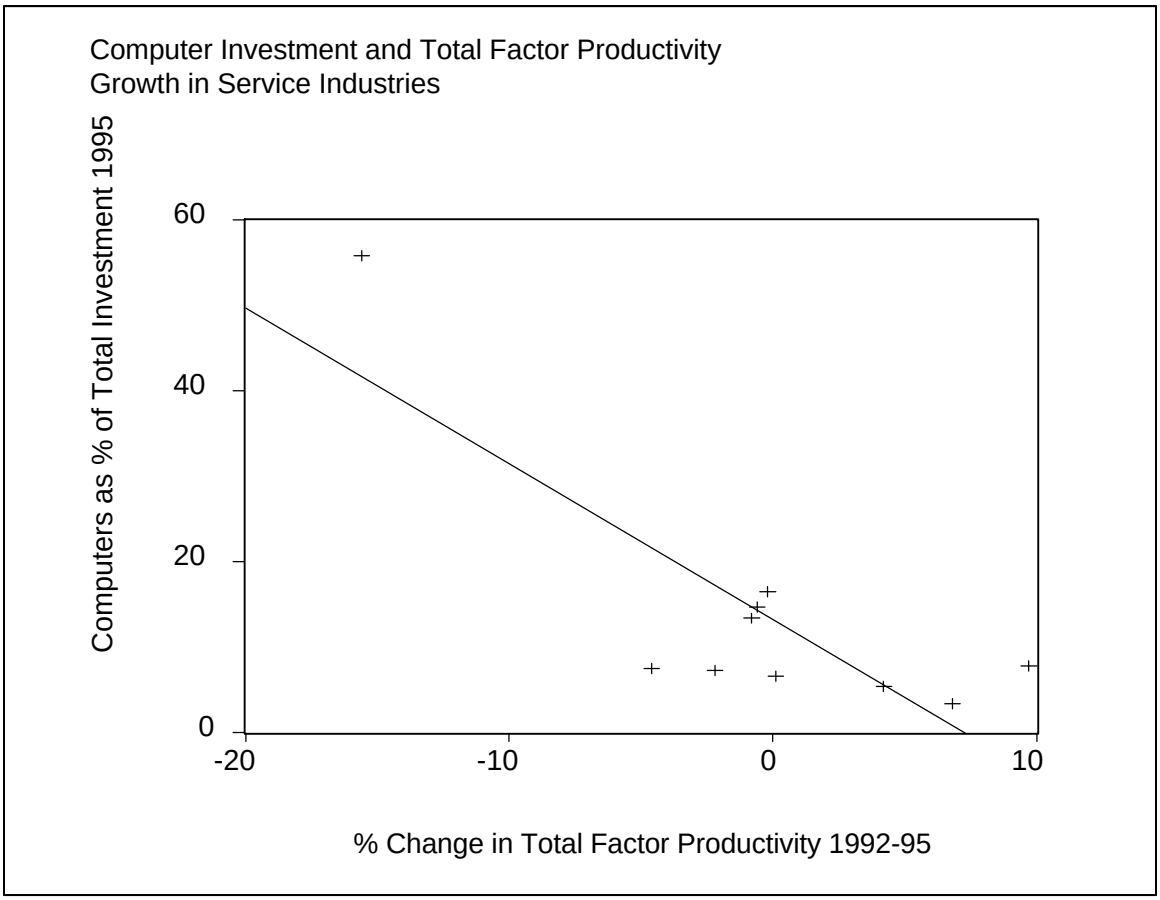
Computer Investment and Total Factor Productivity Growth in Service Industries

	Computers as % Total Investment 1995	% Change in Real Computer Investment 1992-95	% Change in Total Factor Productivity 1992-95
Transportation and storage	3.4	86.8	6.8
Communications and other utilities	7.8	108.3	9.7
Wholesale	14.7	59.1	-0.6
Retail	16.5	351.4	-0.2
Finance, insurance and real estate	13.4	85.8	-0.8
Business services	55.8	3.2	-15.6
Government services	6.6	45.2	0.1
Educational services	7.3	67.0	-2.2
Health and social services	7.5	97.2	-4.6
Hotels and restaurants	5.4	3.4	4.2
Total service sector	9.8	64.2	1.2

Source: Centre for the Study of Living Standards based on Statistics Canada data

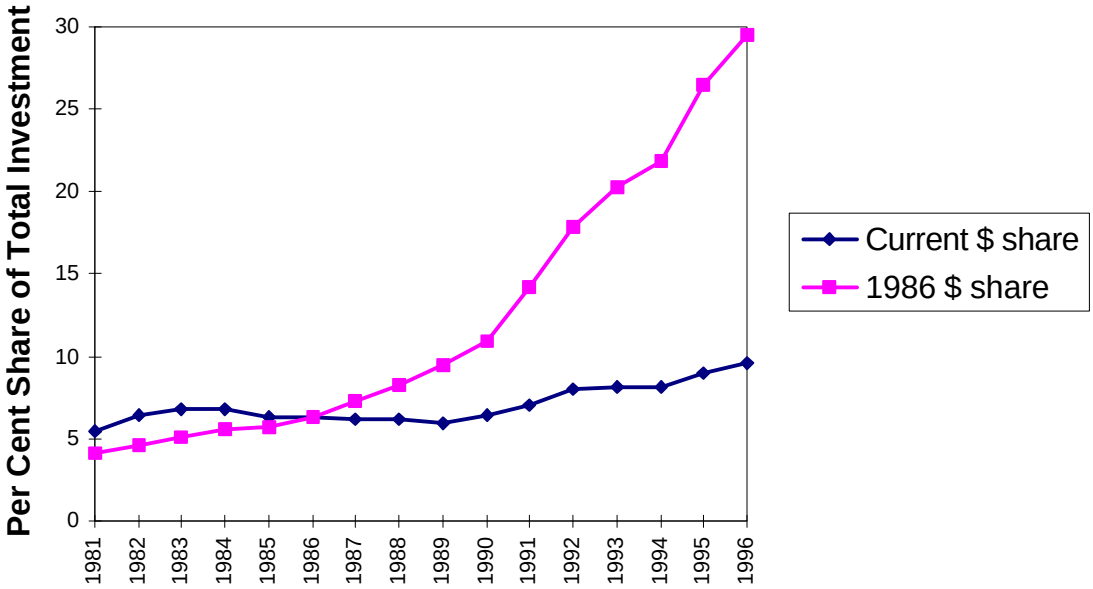
Note: Telecommunications equipment excluded.

Figure 1



Source: Table 1

Figure 2: Investment in Office Machines as share of Total Business Sector Investment



Trends in Business Investments in Office Equipment as Per Cent of Total Business Investments

Year	Current $ share	1986 $ share
1981	5.48	4.10
1982	6.38	4.62
1983	6.78	5.06
1984	6.85	5.57
1985	6.34	5.70
1986	6.32	6.32
1987	6.21	7.34
1988	6.24	8.30
1989	5.99	9.45
1990	6.45	10.91
1991	7.03	14.25
1992	8.04	17.84
1993	8.17	20.29
1994	8.13	21.84
1995	9.03	26.44
1996	9.55	29.51