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The Impact of Information Technology on Labour Productivity in the Service and Trade Sectors of the USA*

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Introduction

The last two decades have witnessed an explosion in the power and capabilities of ordinary computers and information technology equipment in general. Even more interesting, however, is the fact that, between 1960 and 1990, the price of computing, or processing power, in the US shrank in real terms by a factor of 6000 (Economist, 1991, p.30)[1]. Getting more computing power for less money has not escaped the interest of US business enterprises. In 1970, information technology equipment accounted for 11% of all durable equipment purchased by private enterprises; by 1989, that figure had risen to 51% (Economist, 1991, p.30).

Unfortunately, it has been difficult to establish whether the extent of such investments in information technology has resulted in any realized cost savings or any increase in labour productivity. Existing empirical studies of the relationship between information technology deepening and labour productivity have yielded conflicting results. At the aggregate level, Oliner and Sichel (1994) find that information technology does not make a significant contribution to output growth. Using industry level data, Morrison and Berndt (1991) find that computing technology has had only a very small impact on technical progress. In another study, Morrison and Berndt (1992), find that, in most industries, integration of processing power is uncorrelated with multi-factor productivity. Parsons, *et al* (1993) report very low returns for information technology investments for Canadian banks.

1 Throughout this paper terms such as 'computing power', 'processing power' and 'information technology goods' are all used inter-changeably. Further, it is recognized that much of what is being described here as 'computing power' renders inseparable the important distinction between developments in raw processing power and those in software.

On the other hand, Siegel and Griliches (1992) find a positive and statistically significant relationship between a manufacturing industry's rate of investment in information technology equipment and its productivity growth. At the firm level, Lichtenberg's (1993) production function estimating approach finds strong evidence of excess returns to information technology equipment and labour. Further, Lehr and Lichtenberg (1996) estimate a Cobb-Douglas production function for government services and find that use of information technology equipment contributes insignificantly to output growth in Federal government agencies. Finally, Siegel (1997) finds that information technology equipment act as an important source of quality change and that their use is positively related to productivity growth when adjustments are made for measurement errors.

One important aspect of most of this prior research is that almost all of it is focused exclusively on the manufacturing sector. Very few of the earlier studies examined the impact of computers, and information technology goods in general, on labour productivity in the non-manufacturing sectors of the economy. This gap in the productivity research has occurred primarily because output is more difficult to define and quantify in the service and trade sectors than it is in the manufacturing sector. Clearly, counting the output of a steel mill or auto factory is one thing, but it is much more difficult to measure the output of a bank or an insurance company.

Research on the impact of computers and related information technology products on labour productivity in the service and trade sectors is important, especially as the US is becoming more and more reliant on these areas. For example, while the service and trade sectors accounted for over 34% of US GDP in 1994, the manufacturing sector accounted for less than 19% of US GDP in the same year.

The present study will attempt to examine the impact of the use made of information technology goods on labour productivity in the service, wholesale trade, and retail trade sectors. As noted previously, very little prior research has been done in this area. Data on information technology expenditures for the service and trade sectors has only recently become available. The present study is one of the first to utilize this data with the intention of determining the impact of information technology on labour productivity in the trade and service sectors of the United States.

Theoretical Foundations and Empirical Technique

Amongst the more intuitive results found in economic theory is the idea that labour productivity, as measured by the average product of labour, depends upon those factors that affect the ability of the worker to produce. One of the most important of these factors is the amount of capital per employee. Theory suggests that the more capital a worker has to use, the more productive that worker will be. Theory also suggests that this relationship is nonlinear, with the impact of capital per worker on productivity increasing but at a decreasing rate. This relationship can be represented as follows:

$$Q / L = á\ K / L \qquad \ldots (1)$$

where Q denotes output, L denotes labour, and K denotes capital. The first order condition is as follows:

$$[d (Q / L)] / [d (K / L)] = á > 0 \qquad \ldots (2)$$

However, theory also suggests that the second order condition is negative, indicating that the rate of productivity growth falls as the capital-labour ratio rises. This suggests the following to be true:

$$[d^2 (Q/L)] / [d (K/L)^2] = [d á] / [d (K/L)] < 0 \ldots (3)$$

In the present study, computer and information technology equipment will be segregated from other capital equipment in order to examine the impact of these on labour productivity. Since

computers and information technology goods are another form of capital, it is assumed that the nonlinear relationship also exists between information technology and labour productivity; thus, as the computer-labour ratio rises, labour productivity will rise but at a declining rate.

Other factors that may affect productivity include the following: level of education (the more education labour has, the more productive labour should be, holding all other factors constant); the investment rate (the more capital a firm purchases each year relative to its existing stock of capital, the more productive labour should be, holding all other factors constant); and, finally, the level of competition in the industry (the more concentrated an industry is, the greater the level of productivity).[2]

In order to determine the impact of the above factors on labour productivity, the following regression equation will be estimated in the present study:

$$\ln (Q/L) = á_0 + á_1 K/L + á_2 (K/L)^2 + á_3 UNIV + á_4 INV + á_5 CR_4 + á_6 C/L + á_7 (C/L)^2 + á_8 YEAR + á_9 WTRADE + á_{10} SERVICE + u \quad \ldots (4)$$

where Q/L refers to labour productivity, K/L refers to non-information technology capital per worker, UNIV denotes the percentage of the labour in the particular industry being examined that has a college degree, INV is the ratio of current capital expenditures to existing capital stock, CR_4 is the 4-firm concentration ratio which is a measure of industry concentration, C/L denotes the information technology per worker, YEAR is a dummy variable denoting the year 1987, WTRADE is a dummy variable denoting wholesale trade industries, SERVICE is a dummy variable denoting service industries and *u* is a normally distributed, random error term.[3] The capital and information technology variables are in terms of dollars per employee.[4]

2 The impact of concentration on labour productivity is an unsettled issue. Several studies contend that there is a statistically-significant and positive relationship between seller concentration and labour productivity growth (Greer and Rhoades, 1976; Amato and Ryan, 1981). However, other studies find a negative relationship between productivity and concentration (Scherer, 1983; Sveikauskas and Sveikauskas, 1982). Given the uncertainty concerning the impact of concentration on productivity, a seller concentration variable is included in the present study in order to determine if a relationship between these variables exists in the service and trade sectors.

3 Although most studies employ somewhat more sophisticated techniques in order to determine the impact of information technology on labour productivity, the lack of data and the difficulty in obtaining a consistent measure of labour productivity across all service and trade sector industries required the use of a simpler statistical technique.

4 Data on the total amount of information technology in an industry was not available from the Census Bureau for the years 1992 and 1987. The only data available for those years was the amount spent on information technology in a given year. In order to determine the total amount of information technology (C) in the industry, the following methodology was employed. First, the ratio of information technology expenditures (CE) to total capital expenditures (KE) was calculated for each year as follows, this gives the ratio CY:

$$CY = CE / KE$$

This ratio was then multiplied by the total amount of existing capital (K) in order to determine the total amount of information technology (C) in a given industry for a given year:

$$C = CY * K$$

This methodology, of course, assumes that the ratio of current computer expenditures to current capital expenditures equals the ratio of total computer equipment to total capital stock. In addition, no data on information technology operating and support costs were available.

The dependent variable, labour productivity, is a particularly difficult variable to define in equation (4). Ideally, labour productivity, or average product, should be in terms of units produced per worker in a given time period. Unfortunately, as noted previously, most service industries, such as advertising agencies or employment agencies, do not have clearly defined measures of output. Granted, for some service industries, such as the barber industry, output is clearly identified. Unfortunately, data on individual haircuts is not an item reported by the Census Bureau. Hence, the lack of measurable output and/or the lack of data has prompted us to use revenue per worker (in constant dollar terms) as a measure of average product. Although this measure may introduce an element of bias, especially in those industries that produce high value added products, this compromise measure was necessary in order to ensure a reasonable sample size and an ample cross section of service-oriented industries. In addition, the use of this productivity measure is supported by prior research (see, for example, Bailey and Gordon, 1988). Finally, since the above measure of labour productivity varies greatly from industry to industry, the logarithm of this variable is used in order to compress the scale of the data.

Given anecdotal evidence and the results of prior research, it is expected that the results will indicate that computers and other information technology goods have a modest impact on labour productivity in the service and trade sectors (see, for example, Brand and Duke, 1982; Diebold, 1990; Parsons, Gotlieb, and Denny, 1993; Lehr and Lichtenberg, 1996). Capital per labour ratios, education levels, and industry concentration levels should all have positive effects on labour productivity. The following section discusses the data used in the present study and the results obtained.

Data and Results

Equation (4) was estimated for 129 two-, 3- and 4-digit SIC retail trade, wholesale trade and service industries, 78 of which are for the year 1992 and the remainder are for 1987. Industry-specific data was obtained from the 1992 and 1987 Censuses of Wholesale Trade, the 1992 and 1987 Censuses of Retail Trade, and the 1992 and 1987 Censuses of Service Industries. Data on the percentage of the industries' workforce that has a college degree was obtained from two sources. For 1992, industry averages were obtained from a sample of 155,000 respondents from the Current Population Survey. For 1987, industry averages were obtained from a sample of 8931 respondents from the National Longitudinal Survey of Youth. All dollar values were deflated using the Producer Price Index for finished goods, base year 1982.[5]

Descriptive statistics for the data used in the present study are presented in Table 1. Regression results are presented in Table 2.

Results suggest that information technology has had a positive impact on labour productivity as measured in the present study. In addition, as theory would suggest, the effect of information technology on productivity is nonlinear in nature; in other words, the effect of this type of input on productivity is positive but decreasing. This result is somewhat stronger than the results of earlier works for two important reasons. First, most prior works on productivity in the non-manufacturing sectors focused on only one or two narrowly defined industries, such as commercial banking or government services. The present study is the first study that uses a large cross section of trade and service industries and still finds that information

5 Ideally, industry-specific producer price indices (PPI) would be used to deflate the revenues of the individual industries. Unfortunately, such PPI data was not collected in 1987 or 1992 for the service and trade industries examined in the present study.

technology has had a positive effect on labour productivity. Second, this is the first study that empirically corroborates the nonlinear effect of computers on labour productivity in the trade and service sectors. However, it is important to note that this result only applies to labour productivity as defined in the present paper. In addition, given the empirical technique employed in the present study, measures such as output elasticities could not be calculated. Instead, only causal relationships can be surmised from the results of the present study.

Concerning the other variables, most were statistically significant with the expected signs. The capital-labour ratio was positive but nonlinear in nature. The wholesale trade dummy variable was significant and positive, while the service industry dummy variable was significant and negative. All other variables had the expected signs but were insignificant.

Concluding Remarks

The present study attempted to determine the effects of information technology on labour productivity in the trade and service sectors of the US economy. Employing data from the Census Bureau on information technology expenditures for 129 two-, 3-, and 4-digit SIC industries, the present study finds that information technology has had a positive impact on labour productivity in the trade and service sectors of the US economy. This is one of the first studies that not only uses the most recent Census Bureau data on information technology expenditures but also employs a very broad cross section of trade and service industries to reach its conclusions.

Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation
Q/L	194.0515	252.1478
K/L	24.8727	29.38
C/L	2.5003	4.4718
INV	0.1241	0.075
UNIV	0.1957	0.1106
CR_4	0.1426	0.1028
WTRADE	0.2636	0.4423
SERVICE	0.5349	0.5007
YEAR	0.3953	0.4908

Table 2: Regression Results

Variable	Coefficient	Test Statistic
Constant	3.9882	21.893
K/L	0.02008	4.842
$(K/L)^2$	-0.00007	-2.986
C/L	0.1165	3.945
$(C/L)^2$	-0.00354	-2.616
INV	0.36804	0.569
UNIV	0.35797	0.851
CR_4	0.2687	0.588
WTRADE	1.2759	9.949
SERVICE	-0.8779	-7.418
YEAR	0.1129	1.294

R^2 = 83.4%
F Test Statistic = 59.29

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Book Review:

Paul Krugman. The Accidental Theorist – And Other Dispatches from the Dismal Science. Published by Penguin Books, 1999. PP 204. ISBN 0 14 028686 1.

Over the last 10 to 15 years there has been an explosion of interest in all types of material written on or about topics in business, economics and management. Heightened levels of business and economic uncertainty have helped fuel interest in anything purporting to offer an explanation for what's really going on in the world. The number, and apparent influence, of the economic and business gurus willing to provide 'answers' has grown rapidly to meet the burgeoning interest.

If Paul Krugman's *Accidental Theorist* has a central message this is that there has been too much silly 'explaining' and 'answering', much of which has been offered by people who ought to have known better. For the uninitiated knowing that this is Krugman's message should render it wholly believable. Krugman is amongst the most highly rated academic economists of his generation (winning the John Bates Medal in

the early 1990's amongst his many achievements). He is one of a small handful of economists capable of writing for both a professional audience of peers and for the general public. In both roles he has excelled, perhaps without an equal.

Of course, Krugman is not alone in his detection of the profusion of false and falsified economic reasoning. But he is probably the most vocal of the (still relatively young) grandmasters of the profession who has devoted considerable energy to exposing many of the scams that abound. Understandably for this he has won great acclaim and, from obvious quarters, some derision as well.

In the *Accidental Theorist* he brings together 27 short essays many of which have previously been published in popular sources (mostly in the New York Times Magazine, the Economist, Slate and USA Today, between October 1995 and August 1997). To say that these essays are written in a lucid and convincing style surely understates their value. Despite the fact they represent a collection of already published short articles, they retain much relevance, if only to warn would-be scam-mongers of the willingness of publishing houses to help propagate sound exposés and rebuttals.

Apart from this, the essays are witty, persuasive and well-researched as well. As with his other popular writings Krugman manages to pack in a considerable amount of economics here too. The essays are grouped in 6 parts allowing the individual contributions to tackle a wide range of material from the wrongs of supply-side economics, to globalization, to the technology paradox, to income inequality in the US, etc, etc. Identifying a favourite well-written essay will always be a problem; however, choosing favourite topics is not. One of my favourite topics within the collection is *Globalization and Globaloney*. Here, amongst other issues, Krugman presents a robust defense of the links between greater dependency in trade, and economic ties in general, and improvements in living standards (measured relatively of course) across the globe.

Within the pages of this book one encounters a highly respected academic economist with considerable 'street cred' and plenty of political savvy. Krugman the intellectual adventurer is ever present as well.

The complete 204 pages of this book were the fastest that I recall I have ever read. If the prospect of shattering well-known ideas (myths?) appeals to you then, like me, you will find it difficult to resist this collection. Krugman's colleagues at MIT will undoubtedly find it difficult to fill the void that will be left through his departure to Princeton this fall.

Parviz Dabir-Alai

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September 6-8, 2000: 32nd annual conference of the Money, Macro and Finance Research Group, to be held in London, UK. Participants include Joseph Stiglitz and Philip Arestis. Please contact through website: www.sbu.ac.uk/cibs/mm&fg

October 5-6, 2000: International Conference entitled 'Issues and Options for the Multilateral, Regional, and Bilateral Trade Policies of the United States and Japan, to be held in the USA. Contact: Professor Robert Stern at the University of Michigan, Ann Arbor. e-mail: rmstern@umich.edu

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Appreciation:

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