A FIRM LEVEL STUDY OF INFORMATION TECHNOLOGY PRODUCTIVITY IN EUROPE USING FINANCIAL AND MARKET BASED MEASURES

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ABSTRACT

For many years, business has invested significant resources in information technology, hardware, software, and manpower. The Productivity Paradox is the seeming lack of productivity gains despite the increased investment in IT. For many years the existence of a Productivity Paradox has been the subject of research interest. Conflicting results have been obtained from a variety of data sets. Until this time however there has been no study that has investigated European companies' use of information technology and its impact on productivity.

The objective of this study was to investigate information technology productivity with a new data set from a European published source, and measuring productivity using both market and financial based measures.

Results of the study indicated that information technology did have a consistent positive impact on firm level productivity in Europe for the years 1996, 1997, and 1998. Both market and financial based productivity measures provided consistent positive significant returns with regard to IT productivity.

The major contribution of the study is that it provides an analysis of the impact of European information technology on firm and economic productivity.

Since 1987, many researchers such as Erik Brynjolfsson, Paul Strassman, and Loren Hitt have studied the problem of whether the huge investment in information technology (IT) has had a positive impact on overall productivity in the economy and specifically on the firm. A variety of data sources has been analyzed across different perspectives and researchers have come to different conclusions on this central question.

The Productivity Paradox concept started in 1987 with Robert Solow, the Nobel prize-winning economist, who said that computers can be seen everywhere but in the productivity statistics (Solow, 1987). The Paradox as presented by Strassmann is that, despite large investments in information technology, productivity as measured by cost of goods sold has not increased (McCune, 1998). Loveman, in 1988, studied information technology capital versus output over a five-year period, and found no correlation between information technology spending and output increase (Brynjolfsson, 1993). The Productivity Paradox simply stated that empirical investigations in the late 1980s and early 1990s seemed to show that information technology investments, by a variety of measures, were not contributing to overall productivity gains. Since the late 1980s, however, a series of studies have provided different, more positive results for information technology investments. The studies have included Brynjolfsson and Hitt (1996), Bharadwaj, Bharadwaj, and Knosynski (1999) and Dewan and Kraemer (1998).

RELEVANCE OF THE STUDY

The general question addressed in this research is similar to many previous studies, i.e., does investment in information technology have a significant positive effect on overall firm productivity and performance. This work, however, adds to the literature in several ways:

1. This empirical study analyzes both market based and financial productivity measures.
2. This research examines current information.
3. It includes European firms.

BARRIERS AND ISSUES

As with any empirical research, the biggest challenge was to find an appropriate data source to empirically investigate the proposed research problem.
The first step in obtaining a data set was to review the data sets used by other researchers in the field. The data sources for the studies presented in the literature search vary from government sources to major publications' survey data, to private empirical surveys. A data set heretofore unanalyzed was the Top 100 IT spenders in Europe from the publication Information Strategy.

HYPOTHESES TO BE INVESTIGATED

This study empirically investigates the following research hypothesis: Positive productivity gains are recognized for both European firms, in the recent time frame, from information technology investment.

SIGNIFICANCE OF THE STUDY

This study represents a significant research issue due to the sheer size of information technology spending in the economy as a whole, and its expected positive impact on firm level productivity. The significance of the study is that 32.5% of all business capital investment is IT related, not including software and systems development. (Dos Santos, Peffers, and Mauer, 1993) This is a very significant expenditure for business. It should be determined whether IT increases productivity.
The study of the productivity impact of information technology on organizations started slowly. Though commercial applications for computer technology started in the late 1950s and accelerated through the 1960s and 1970s, there was little research on measuring the benefits gained from information technology spending. The implementation of management information systems and related technology were accepted in organizations through the perceived savings in manpower gained from automating clerical tasks such as payroll, accounts payable, and other financial applications. But beginning in the early 1980s, researchers tried to measure the impact that IT was having on the individual firm, in specific applications, and on the economy as a whole. No significant studies focusing on IT productivity were developed until the early 1980s. Then the pace of studies significantly accelerated and reached its peak in the period 1987-1995. Results from two decades of studies have resulted in little consensus on whether IT spending is having a significant favorable impact on individual firms or the economy as a whole.

DATA COLLECTION

As noted, the data source for this study was culled from a published source. Information Strategy, a United Kingdom publication, prepares an annual survey of the top 100 information technology spenders for European businesses. Data were obtained from this organization.
All IT expenditures and personnel information were supplemented with published financial data from Compustat and Standard and Poor's financial publications and databases. Least squares regression methods were used to determine the impact of information technology expenditures on firm productivity. Both market based and financial productivity measures were reviewed and tested prior to use. Specific financial and market based measures were determined through analysis of Compustat and other data sources, and included generally accepted measures such as return on sales, return on equity, Tobin's q, market value per share, and return on assets.

APPROACH

The approach of this study was an empirical analysis at the firm level using financial and market based measures. Firm level data were used since most researchers suggest it provides the most accurate indicator of information productivity in the economy as a whole. Macroeconomic studies are affected by other significant economic factors and deal only with aggregate data. Application

level studies cannot be extrapolated to the economy as a whole. Firm level studies as performed by Brynjolffson and Hitt (1996, 1998a), Lehr and Lichtenberg (1999), and Kwon and Stoneman (1995) have proven the most reliable. This study uses the same methodology as a study by the author on US firms (Peslak, 2003).

The data were entered into separate Excel spreadsheets. Financial and market information was obtained from the Compustat Global database. The global database information was obtained through Nova Southeastern University and School of Computer and Information Sciences.

The information obtained from the Compustat global database was used to prepare the financial and market based performance measures. The information is noted in Table 1.

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TABLE 1. COMPUSTAT DATA

General company information	**Financial data**	**Financial ratios**	**Market ratios**
Company name	Current assets	Return on assets – ROA	Price/earnings ratio – PE ratio
Primary SIC code	Current liabilities	Return on Equity – ROE	
Industry group	Total assets	Return on investment – ROI	
Employees	Total long-term debt	3 Year return %	
	Sales		
	Current liabilities		
	Cash flow		
	Earnings before interest and taxes		
	Market data		
	Shares outstanding		
	Stock price		

From these data other measures were calculated including

- Market value = Shares outstanding X Market price
- Current ratio = Current assets / Current Liabilities
- Non-current assets = Total assets – Current assets
- Capital Intensity = Sales / Capital
- IT spending as a percent of sales
- Tobin's q (defined in Chapter 1)
- Market to book ratio (market value/book value)
- Market to cash flow ratio (market value/cash flow)
- Debt to asset ratio (Debt/assets).

The financial measures were

- Return on assets
- Return on equity
- Return on investment
- EBIT -- earnings before interest and taxes
- Three-year return
- Cash flow.

Market based measures were

- Tobin's q.
- Market value
- Price/earnings ratio
- Market price to book ratio
- Price/cash flow per share.

These served as the dependent variables, or IT productivity measures. The key independent variable was some measure of information technology expenditures.
For the regression analyses performed, linear equations were used for all analyses as well as the Cobb-Douglas production function for non-ratio analyses. Ordinary least squares regression analysis was performed on the data sets.
A new analysis was performed on the Information Strategy European database and global Compustat databases to determine whether similar productivity gains were recognized in the time period 1996 -- 1998 for European firms. The general form of the non-ratio equation was

Performance index (x)= a + b Current Assets +
c Total Assets+
d Total Long-term Debt+
e Total Sales+
f Total IT Budget+
g Total Non-current Assets+
h Number of Employees.

The equation was
x = a + b CA + c TA + d TLTD+ e TS +f ITBUD + g TNCA + h EMP.

The dependent performance measures were tested against these independent variables -- cash flow, earnings before interest and taxes, and market value. The Cobb-Douglas production function was used for these dependent variables. The equations were changed as follows:

Log Performance index (x)= a + b log Current Assets +
c log Total Assets+
d log Total Long-term Debt+
e log Total Sales+
f log Total IT Budget+
g log Total Non-current Assets+
h log Number of Employees.

The equation was
Log x = a + b log CA+ c log TA + d log TLTD+ e log TS +f log ITBUD+ g log TNCA + h log EMP.

The dependent performance measures were tested against the noted independent variables – log cash flow, log earnings before interest and taxes, and log market value.
Ratios were also used on the Information Strategy database as performance measures. The form of the equation and the independent variables were as follows:

Performance index (x)= a + b IT as Percent of Sales+
c Capital Intensity+
d Debt to Assets Ratio+
e Current Ratio

The equation was x = a + b IT+ c CI + d DTA+ e CR.

The following dependent performance measures were tested against these independent variables – Market to Book ratio, Market to cash flow, PE ratio, ROA, ROE, ROI, Tobin's q, and 3 year return percent.
For the 14 performance measures tested, the overall adjusted R^2 (coefficient of determination) was calculated as well as the IT variable correlation coefficient and its significance. A p value of .05 was used as the threshold for significance of the independent variable on the dependent performance measure. The significance of other independent variables was also reviewed.

This analysis proceeded through each year of the Information Strategy data 1996, 1997, and 1998. The results were then reviewed to determine whether the results have been consistent for the period 1996-1998 for European firms.

RESULTS

The result tables use abbreviations for each dependent variable performance measure. The explanations of these abbreviations are shown in Table 2.

Table 2. Performance Measures

Abbreviation	Measure	Type of Measure
3YR	3 Year Return	Financial
CF	Cash Flow	Financial
CFL	Log Cash Flow	Financial
EB	Earnings Before Interest and Taxes	Financial
LEB	Log Earnings Before Interest and Taxes	Financial
LMV	Log Market Value	Market
MV	Market Value	Market
MTB	Market to Book Ratio	Market
MTC	Market to Cash Flow Ratio	Market
PE	Price/Earnings Ratio	Market
ROA	Return on Assets	Financial
ROE	Return on Equity	Financial
ROI	Return on Investment	Financial
TOB	Tobin's q Ratio	Market

The database from Information Strategy was assessed with the noted financial and market measures. The first year analyzed is shown in Table 3. In eight of the 13 measures, which could be tested, information technology expenditures were significant and positive. (One measure, market value log, was unable to be calculated because of insufficient data points). Total observations were fairly small however, at 13 to 16 observations. But for cash flow, market value, market to book value, return on assets, return on equity, return on investment, Tobin's q and 1-year return (3 year return was unavailable for the International database), significant and positive correlation coefficients were recorded.

Table 3. 1996 Information Strategy European Summary

Measure	AdjR^2	Overall p	IT Coefficient	IT p Value
CF	0.938	0.0005	2.613	0.041
EB	0.584	0.025	3.424	0.068
MV	0.794	0.01	30.964	0.048
CFLOG	0.987	0.081	-3.169	0.131
EBLOG	0.82	0.296	-4.106	0.401
MVLOG	NA	NA	NA	NA
MTB	0.916	0.0005	51.782	0.0005
MTC	-0.35	0.878	74.838	0.672
PE	-0.404	0.926	7.046	0.992
ROA	0.54	0.008	116.499	0.001
ROE	0.337	0.061	218.133	0.011
ROI	0.513	0.011	187.234	0.002
TOB	0.921	0.0005	28.609	0.0005
3YR	0.348	0.056	1.278	0.012

In the 1997 analysis of top European firms, the number of factors significant and positive was reduced, however. Only five of 14 were significant and positive at the $p < .05$ level. They were market to book, market to cash flow, Tobin's q, 1 year return, and return on assets. At the $p < .10$ level two more factors would be included, earnings before interest and taxes, and market value. Complete results are shown in Table 4. The number of data points rose to 22 to 26 depending on the dependent performance measure.

Table 4. 1997 Information Strategy European Summary

Measure	AdjR^2	Overall p	IT Coefficient	IT p Value
CF	0.16	0.21	-0.0966	0.974
EB	0.713	0.0005	1.577	0.067
MV	0.638	0.0005	15.358	0.075
CFLOG	-0.599	0.772	0.0793	0.967
EBLOG	-0.077	0.669	-0.0249	0.988
MVLOG	0.584	0.288	0.08213	0.946
MTB	0.24	0.03	11.749	0.011
MTC	0.623	0.0005	38.691	0.002
PE	0.126	0.165	38.698	0.151
ROA	0.379	0.003	27.911	0.0005
ROE	0.103	0.154	7.381	0.797
ROI	0.227	0.032	10.475	0.516
TOB	0.439	0.001	8.806	0.0005
3YR	0.919	0.0005	2.106	0.0005

The final year of the Information Strategy database available and analyzed was 1998. This year generally had 40-60 observations. Here, once again, there were eight measures that had significant p values (at $p < .05$) for the information technology spending coefficients. The coefficients for cash flow, earnings before interest and taxes, market value, cash flow log, market to book, return on assets, return on investment, and Tobin's q all were positive. This suggests a positive correlation between information technology expenditures and the dependent performance measure. Another

factor, return on equity, was positive and significant at the $p < .10$ level. Complete details are shown in Table 5.

Table 5. 1998 Information Strategy European Summary

Measure	AdjR^2	Overall p	IT Coefficient	IT p Value
CF	0.886	0.0005	5.401	0.0005
EB	0.754	0.0005	3.768	0.0005
MV	0.356	0.0005	79.726	0.001
CFLOG	0.795	0.0005	0.447	0.046
EBLOG	0.755	0.0005	0.236	0.109
MVLOG	0.17	0.155	0.539	0.193
MTB	0.142	0.012	102.418	0.002
MTC	-0.077	0.937	56.737	0.632
PE	-0.065	0.865	-14.153	0.922
ROA	0.183	0.003	137.869	0.0005
ROE	0.12	0.022	319.641	0.071
ROI	0.253	0.0005	390.652	0.0005
TOB	0.106	0.034	44.695	0.002
3YR	-0.01	0.484	5.932	0.25

Examining the European Information Strategy information, overall, from a financial versus market measure perspective results in Tables 6 and 7. Table 6 shows the European results for the 3 years for all financial measures. Twelve of the twenty-four analyses demonstrate strong positive relationships between information technology and the dependent performance measure significant at the $p < .05$ level. Of these, return on assets was positive and significant at the $p < .05$ level for all three years.

Table 4-36. IS Financial European Summary

Year	Measure	AdjR^2	Overall p	IT Coefficient	IT p Value
96	3YR	0.348	0.056	1.278	0.012
97	3YR	0.919	0.0005	2.106	0.0005
98	3YR	-0.01	0.484	5.932	0.25
96	CF	0.938	0.0005	2.613	0.041
97	CF	0.16	0.21	-0.0966	0.974
98	CF	0.886	0.0005	5.401	0.0005
96	CFLOG	0.987	0.081	-3.169	0.131
97	CFLOG	-0.599	0.772	0.0793	0.967
98	CFLOG	0.795	0.0005	0.447	0.046
96	EB	0.584	0.025	3.424	0.068
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96	EBLOG	0.82	0.296	-4.106	0.401
97	EBLOG	-0.077	0.669	-0.0249	0.988
98	EBLOG	0.755	0.0005	0.236	0.109
96	ROA	0.54	0.008	116.499	0.001
97	ROA	0.379	0.003	27.911	0.0005
98	ROA	0.183	0.003	137.869	0.0005
96	ROE	0.337	0.061	218.133	0.011
97	ROE	0.103	0.154	7.381	0.797
98	ROE	0.12	0.022	319.641	0.071
96	ROI	0.513	0.011	187.234	0.002
97	ROI	0.227	0.032	10.475	0.516
98	ROI	0.253	0.0005	390.652	0.0005

The market measures shown in Table 7 show similar strength in relationships between information technology expenditures in European firms and productivity. Nine of the seventeen analyses showed positive and significant (at $p < .05$) relationships. The Tobin's q measure was significant at $p < .05$ and its correlation coefficient was positive in all three years analyzed. The results of the Information Strategy database thus confirm the conclusion that there is no significant difference between financial and market based measures in determining information technology productivity.

Table 7. IS Market European Summary

Year	Measure	AdjR^2	Overall p	IT Coefficient	IT p Value
96	MTB	0.916	0.0005	51.782	0.0005
97	MTB	0.24	0.03	11.749	0.011
98	MTB	0.142	0.012	102.418	0.002
96	MTC	-0.35	0.878	74.838	0.672
97	MTC	0.623	0.0005	38.691	0.002
98	MTC	-0.077	0.937	56.737	0.632
96	MV	0.794	0.01	30.964	0.048
97	MV	0.638	0.0005	15.358	0.075
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96	MVLOG	NA	NA	NA	NA
97	MVLOG	0.584	0.288	0.08213	0.946
98	MVLOG	0.17	0.155	0.539	0.193
96	PE	-0.404	0.926	7.046	0.992
97	PE	0.126	0.165	38.698	0.151
98	PE	-0.065	0.865	-14.153	0.922
96	TOB	0.921	0.0005	28.609	0.0005
97	TOB	0.439	0.001	8.806	0.0005
98	TOB	0.106	0.034	44.695	0.002

Overall it can be stated that a significant positive relationship was generally established between information technology expenditures and European firm level productivity. The hypothesis was supported.

CONCLUSIONS AND IMPLICATIONS

The overall objective of the study was to determine whether a Productivity Paradox existed and currently exists at the firm level for European firms. In other words, the question was whether information technology had a positive impact on European firm level productivity. The results of the study generally found a positive relationship between IT spending and firm level productivity for European firms. A Productivity Paradox at the firm level was not observed in this study.

ANTICIPATED BENEFITS

The implications of the findings may influence corporate spending on information technology in Europe, since information technology expenditures generally added to the productivity of the European firm. Positive correlation between IT spending and productivity for European firms was found to exist. However, IT spending should be scrutinized closely. A relationship was found for European firms, but not all years and productivity measures were affected. Care must be taken with European IT expenditures. This study advances knowledge of the impact of information technology spending for current time frame, international analyses, using both financial and market based measures.

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