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Does the Non-innovative IT Explain the "Productivity Paradox"?

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DOES NON-INNOVATIVE TECHNOLOGY EXPLAIN THE "IT PRODUCTIVITY PARADOX"?

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ABSTRACT

Contrary to theoretical arguments that suggest a positive association between investment in IT and improved financial performance, some empirical evidences suggested that no statistical association between IT spending and financial performance. This phenomenon is known as the "IT productivity paradox" Dos Santos et al. [21] argued that non-innovative technologies are not likely to improve a firm's market value or financial performance. Automatic teller machines (ATMs) are one of the well-known and non-innovative representatives of IT investment. By examining the relationship between ATMs investment and financial measures, we find that ATMs investments improve financial performance and lower cost rates, but no consistent conclusion on the measures of growth. Contrary to Dos Santos et al. [21] which argued that non-innovative technologies are not likely to improve a firm's market value or financial performance. The empirical results show that the phenomenon of "IT productivity paradox" does not come out in this case. The non-innovative technologies do not always result in productivity paradox.

INTRODUCTION

For the past half-century, modern organizations have been increasing their investments in information technology (IT). In a 1996 survey, The Economist reports that America's investment in computers has risen by 20-30% a year in real terms; the share of IT in firms' total equipment investment has jumped from 7% in 1970 to over 40% in 1996[7]. The IT spending in 2001 for the United States and Japan were $546,681 and $188,012 (in millions of US dollars), respectively [29]. Firms invested in IT presumed that such investments could enhance their efficiency, performance and reinforce their competitive edges. IT has played an increasingly important role in modern organizations and the business value of IT investment has become a crucial but controversial issue.

Contrary to theoretical arguments that suggest a positive association between investment in IT and improved financial performance, some empirical evidences, especially in 1980s and early 1990s, suggested that no statistical association between IT spending and financial performance. This phenomenon is known as the "IT productivity paradox" and debated for the past decade [12, 13, 26]. Dos Santos et al. [21] argued that non-innovative technologies are not likely to improve a firm's market value or financial performance. The IT investments were classified as non-innovative if the investment was following investments already made by its competitors; or the investment was intended to maintain an existing application. The innovative investments represented the first use of a technology within the industry, or would result in a new product or service based on information technology, or the development of new information technology for the industry. So the firms which invest in innovative may take more risk and cost more money.

For banking industry, applications of information technology have been prevailing for many years, especially for the automatic teller machine (ATM). Nowadays, ATMs are one of the well-known representatives of IT investment and have been utilized for several decades. And the banks that invested in ATMs are intended to maintain an existing application. Following the definition of Dos Santos et al. [21], the investment on ATMs should be classified as non-innovative. We wonder if the follow-up investment can not enhance efficiency or performance, why the banks are willing to invest in ATMs continuously so many years. It seems very worthy to revisit the relationship between non-innovative IT investment and firm's performance, and search some explanations for banks which continuously invest in ATMs.

Strassmann [36] claimed that the productivity impact of a new technology takes time to materialize. Brynjolfsson [12] suggested that one of the explanations for the IT productivity paradox is time lags due to learning and adjustment. ATM is not a new technology utilized by banks, and has been accepted by the clients. Studying the relationship between ATMs and performance will not encounter the time lags proposed by Strassmann [36] and Brynjolfsson [12] which may cause the productivity paradox. From the empirical results, we find that ATMs investment leads better financial performance and lower cost rates, but no consistent conclusion on the measures of growth. The main contribution of this paper is that this paper provides evidence to invest on non-innovative IT. As we know, the investment of new technology is risky and will incur large fixed cost, especially for innovative IT. The firms in some industries, for example the banking industry and airline industry, are not adaptive to take this kind of risk. They may be seriously affected if their IT-based system failed even for a short time. This paper can provide some evidence to support the adoption of non-innovative IT, and future insights to assess the IT investment project.

The data used in this paper are mainly extracted from the Bureau of Monetary Affairs, Financial Supervisory Commission at Taiwan. Further, the data set is composed of 35 banks, and the time period of this empirical study is from 1995 to 2005.

LITERATURE REVIEW AND IT PRODUCTIVITY PARADOX

Porter and Millar [33] suggested that IT has affected competition in three aspects. First, IT has led to changes in industry structure and competition. Second, IT was used to support the creation of new business. Third, companies using IT outperformed

the corrivals. From the strategic point of view, IT could affect the strategies, including cost leadership, differentiation or specialization in a market niches, or efficiency in the activities involved in the value chain [32]. Besides, IT could reduce the cost of coordination between activities and risks inherent to the transaction and create value for the client [4, 14].

Over the last two decades, scopes of papers and books have been devoted to the issue of IT and productivity or financial performance. Some studies found that IT could improve productivity [2, 31, 24]. Some prior studies found that IT could not improve productive [7, 9, 29, 34, 37]. The term "IT productivity paradox" was introduced to describe the phenomenon that no statistical association between IT spending and financial performance [12], 24]. Productivity paradox was originally defined at the economy level [12]. Most of researchers have addressed the productivity issue at the firm level [18]. This phenomenon also exists in the research of banking industry [6].

Strassmann [36] examined the relationship between productivity and computers. He found that no links between computers and productivity and provides several explanations for the paradox. First, the data used in his work was collected on a marco level. It is highly aggregated and may not capture the reality very well. Second, the productivity impact of a new technology takes time to materialize. Third, at the corporate level, computers may help enterprise stay in the race, but not increase competitiveness. Brynjolfsson [12] suggested four explanations for the IT productivity paradox. The first is mismeasurement of output and input. The second explanation is time lags due to learning and adjustment. The third explanation is that of redistribution of profits. The fourth explanation is that IT is not really productive at the firm level.

Other studies offered different explanations for productivity paradox. Based on economic theory, innovators may obtain superior performance if they can capture favorable market positions, secure scarce resources, etc, before their competitors can imitate them. So the innovative investments in IT may result in greater rewards for investors than follow-up investments. Following this logic, Dos Santos et al. [21] argued that non-innovative technologies are not likely to improve a firm's market value or financial performance. Stratopoulos and Dehning [38] argued that productivity paradox is due to the fact that companies implement IT projects ineffectively. Like other assets, IT must be utilized effectively to result in increased financial performance. Successful users of IT have superior financial performance relative less successful users of IT. Dehning, Dow and Stratopoulos [16] proposed that IT might increase organizational slack, but neither organizational output nor profit. One possible source of productivity paradox was the increased slack. Besides, the structure of market might cause the productivity paradox, Belleflamme [7]suggested that in the oligopolistic competitive market each individual firm might find it is profitable to invest in cost-reducing IT, but total investment might then be excessive from the industry's point of view.

There are several kinds of performance measures used in correlative studies. The measures of productivity were used in Cron and Sobol [15], Bender [8], Dos Santos et al. [21], Strassman [36], Hitt and Brynjolfsson [26], Weill [39], Dewan and Min[19], and Dewan and Kraemer[20]. The measures of profitability were used in Cron and Sobol [15], Bender [8], Dos Santos et al. [21], Strassman [36], Hitt and Brynjolfsson [26]. The measures of consumer surplus were used in Cron and Sobol [15], Bender [8], Bresnahan [11], Dos Santos et al. [21], Strassman [36], Hitt and Brynjolfsson [26]. Mukhopadhyay et al.[30] relied on quality and Banker et al. [5] utilized operational efficiency, and Bharadwaj et al. [10] based on Tobin's q. Recently, Wu and Chen [40] suggested a hybrid performance measure system which is an integrative assessment framework with a three-level structure of corporate strategies, manufacturing decisions, and operational activities. Performance should be examined at different levels. Lin and Shao [29] estimated the IT business value in terms of the impact of IT on technical efficiency, based on the constant elasticity of substitution stochastic production frontier model.

SAMPLE SELECTION AND RESEARCH METHOD

The data used in this paper are mainly from the Bureau of Monetary Affairs, Financial Supervisory Commission at Taiwan. These data belong to 35 banks. In the short run, the investment on information technology is not necessarily related to superior financial performance, but will pay off only in the long term[Kivijarvi and Saarinen [28]. To this end, the empirical period of this paper is from 1995 to 2005 and the total number of sample is 284.

We examine the dependent factors from three firm perspectives, namely financial profitability perspective, operating cost perspective, and growth perspective. The profitability measures are return on assets (ROA), return on equity (ROE), net income rate (NIR), and operating income rate (OIR) (Stratopoulos and Dehning, [38]). Previous papers indicated that IT could reduce the cost of coordination between activities and risks inherent to the transaction and create value for the client [1, 4, 14]. The cost measures should be treated as performance measures. The cost measures are operating expense rate (OER), employee fee rate (EFR) and finance cost rate (FCR), and the revenue-expense rate (RER). And the growth measures are the growth rate of sales (GRS), growth rate of gross margin (GRNI), growth rate of operating income (GROI) and growth rate of ROA (GRRO).

The problem what we concern is whether the ATMs investment will lead the financial performance or not. Here we propose a simple regression model that regressed performance measures on the number of ATMs lagged one period along with the control variable reflecting performance measures of previous period. The model as follows:

$$y_t = \alpha_0 + \alpha_1 ATM_{t-1} + \alpha_2 \Pr e - Ratio + e \quad (1)$$

Where

y_t: Financial ratios of period t; ATM_{t-1}: The log value of the number of ATMs of period t-1; $\Pr e - Ratio$: The Financial ratios of period t-1; α_0: Constant term; α_j: Coefficients of independent variables, j=1, 2; e : Error term.

As pointed out by B. L. Dos Santos and Peffers [22], Innovative information technology (IT) applications are risky investments. Unless successful applications provide innovators with exceptional returns, these investments would not be justified. The business size represents the ability to take risk and become another factor to affect IT adoption. Some researches claimed that

larger banks tend to install more ATMs than smaller banks in order to get the advantage of economic scale and relatively larger banks are likely to get more profit by adopting ATMs ([23], [27]). IT investments may take time to achieve a positive payback and desired return and require additional resource from external stakeholders, such as creditors and investors [17, 25, 35]. So the financial health and operating size of banks may affect the banks' performance.

From the previous paper, we know that the total assets is a very popular proxy for enterprise size. In our case, we find that the number of ATMs and the total assets of banks are highly correlated. The Pearson's correlation coefficient between the log value of the number of ATMs and log value of total assets are 0.874, the P-value for significantly differing from zero is smaller than 0.0001. This fact forces us to give up the consideration of banks' size.

We modify the regression model that take into consideration of the impact of financial health, but out of consideration the effect of size. The proxy of financial health is Z-score which propose by Altman [3]. The regression model is expressed as the equation (2). Again, this regression model is along with the control variable reflecting performance measure of last one period. The second regression model as follows:

$$y_t = \beta_0 + \beta_1 ATM_{t-1} + \beta_2 y_{t-1} + \beta_3 Health_t + \varepsilon \quad (2)$$

Where

y_t: Financial ratios of period t; ATM_{t-1}: The log value of the number of ATMs of period t-1; $Pre-Ratio$: The Financial ratios of period t-1; $Size_t$: The log value of total assets; $Health_t$: The Altman's Z-score; β_0: Constant term; β_j: Coefficients of independent variables, j=1,2,and 3; ε: Error term.

EMPIRICAL RESULTS

Table 1 shows the regression results of equation (1) which simply examined whether the ATM investment would lead the performance. In the circumstance that the profitability measures are the proxies of the financial ratios, the coefficients of ATM_{t-1} are 0.226, 1.312, 3.953, and 4.052 respectively. All of these four coefficients are significantly positive. This figures represent the ATMs investment will lead the ROA, ROE, net income rate, and operating income rate positively. These results are opposite to the evidences of Strassman [36] and Hitt and Brynjoflsson [26]which claimed the existence of productivity paradox.

In the circumstance that the cost measures as the financial ratios, all the coefficients of ATM_{t-1} are negative, they are -0.222, -0.107, -4.344, and -4.052. The independent variable, ATM_{t-1}, has significantly negative impact on FCR and RER. This results shows that the ATMs investment will lower the finance cost rate and revenue-expense rate. Finance costs of banks include the operating expense, promotion expense, and other expense which are relevant with financial transaction. From the transaction cost of view, IT could reduce the cost of coordination and risks inherent to the transaction [14]. These results are consistent with the previous work that the ATMs will cause the cost-saving.

Finally, we check the relationship between the growth rates and the ATMs investment. In the circumstance that the growth measures as the financial ratios, all of four coefficients of ATM_{t-1}, are positive. The coefficients are 0.799, 74.985, 92.039, and 1.333. The ATM_{t-1} has positive and significant impact on the growth rate of ROA only. So the ATMs investment can not improve the growth rate generally and significantly. ATMs are used for cash transactions and for account transfers. The investment of banks on ATMs is intended to maintain an existing application and can not result in a new product or service for the future. It makes sense that ATMs investment can not spur the growth for banks.

In brief, we find that ATMs investment is positively related with profitability measures, and negatively related with cost measures, but no consistent relation exists between ATMs investment and growth measures. The ATMs investment was neither first usage within the banking industry nor result in a new product or service. These empirical results indicate that the ATMs investment, a classical representative of non-innovative technology investment, will lead higher profitability and lower cost. The phenomenon of "IT productivity paradox" does not come out in this case. Contrary to Dos Santos et al. [21] which argued that non-innovative technologies are not likely to improve a firm's market value or financial performance.

Table 2 shows the regression results of equation (2) which examined the impacts of ATMs investment, and financial health on financial ratios along with the control variable reflecting performance measures of last period. From the empirical results, we know that ATM_{t-1} is positively related with profitability measures, and negatively related with cost measures, and there is no consistent relation with growth measures. In the circumstance that the profitability measures are the proxies of financial ratios, the coefficients of ATM_{t-1} are 0.242, 1.833, 3.155, and 2.881. Three of them are significantly different from zero, the coefficient of ATM_{t-1} does not different from zero only in the circumstance that ROE as the financial measure. Again, these figures show the ATMs investment will improve the ROA, net income rate, and operating income rate significantly.

In the circumstance that the cost measures are the proxies of financial ratios, the coefficients of ATM_{t-1} are -0.994, -0.284, -1.962, and -2.881. Only the coefficients of OER and RER are significantly different from zero. This evidence support that the ATMs investment will lower the operating expense rate, and revenue-expense rate. In the circumstance that the growth measures are the proxies of financial ratios, the coefficients of ATM_{t-1} are -0.994, -0.284, -1.962, and -2.881. No consistent and significant relation exists between ATMs investment and growth measures.

In sum, the empirical results of equation (1) and (2) are consistent, basically. Although the ATMs investment does not cause higher growth rate, these empirical results support that the ATMs investment will improve the profitability and cause cost reduction. The phenomenon of "IT productivity paradox" does not emerge. The coefficients of health are positive for the

profitability measures and growth measures and negative for the cost measures. All the coefficients of health are significantly different from zero except when the financial ratio is growth rate of net income. These results imply that the banks with healthy financial status will enjoy the higher profitability, lower cost rate, and higher growth rate.

DICCUSSION AND CONCLUSION

Dos Santos et al. [21] which argued that non-innovative technologies are not likely to improve a firm's market value or financial performance. So the investment on non-innovative technologies may be one of the explanations of "IT productivity paradox". Contrary to the arguments of Dos Santos et al. (1993)[21], this paper find a case that non-innovative technologies can improve the profitability and cost saving. Although the non-innovative technologies can not ensure the competitive edges for the growth in the future. We investigate the banking industry of Taiwan and examine the relationship between ATMs investment and financial measures. The empirical results suggest that the ATMs investment will improve the profitability measures such as ROA, ROE, net income rate, and operating income rate. The empirical results also suggest that the ATMs investment will lower the cost ratio such as the operating expense rate, employee fee rate, finance cost rate, and revenue-expense rate. Besides, the financial health of banks is positive for the profitability measures and growth measures and negative for the cost measures. The banks with healthy financial status will enjoy the higher profitability, lower cost rate, and higher growth rate.

As we know, the investment of new technology is risky and will incur large fixed cost, especially for innovative IT. Investing on non-innovative technology can promote the profitability and reduce the operating cost, it can be a conservative alternative to reduce the investment risk and help firms afford other project which can spur the development and growth.

Table1: Regression results for model (1)

$$y_t = \alpha_0 + \alpha_1 ATM_{t-1} + \alpha_2 \Pr e - Ratio + e$$

Financial ratio	Intercept	ATM t-1	Pre-Ratiot-1	Adjusted R2
Profitability measures				
ROA	-1.088 (-2.85) ***	0.226 (3.11) ***	0.336 (5.99) ***	0.165
ROE	-13.102 (-1.90) *	1.312 (2.17) **	0.024 (0.40)	0.011
NIR	-19541 (-2.67) ***	3.953 (2.85) ***	0.294 (5.16) ***	0.126
OIR	-19.442 (-2.38) ***	4.052 (2.60) ***	0.283 (4.95) ***	0.111
Cost measures				
OER	7.487 (4.09) ***	-0.222 (-0.70)	0.741 (18.08) ***	0.540
EFR	3.371 (3.47) ***	-0.107 (-0.58)	0.767 (18.06) ***	0.553
FCR	76.734 (7.64) ***	-4.344 (-2.77) ***	0.267 (4.61) ***	0.108
RER	91.093 (8.53) ***	-4.052 (-2.60) ***	0.283 (4.95) ***	0.111
Growth measures				
GRS	-0.646 (-0.09)	0.799 (0.60)	0.454 (8.24)***	0.192
GRNI	-511.825 (-1.02)	74.985 (0.79)	-0.042 (-0.70)	0.000
GROI	-616.101 (-2.06) **	92.039 (1.63)	-0.045 (-0.76)	0.003
GRRO	-0.502 (-0.13)	1.333 (1.89) *	0.332 (6.08) ***	0.101
ps: the values in parentheses are t-value; *, ** and *** represent the significant level 0.1, 0.05 and 0.01 respectively.				

Table 2: Regression results for model (1)

$y_t = \beta_0 + \beta_1 ATM_{t-1} + \beta_2 y_{t-1} + \beta_3 Health_t + \varepsilon$

Financial ratio	Intercept	ATM t-1	Pre-Ratiot-1	Health	Adjusted R2
Profitability measures					
ROA	-3.221 (-7.075)***	0.242 (3.01) ***	0.137 (2.33) ***	6.474 (9.68) ***	0.423
ROE	-44.950 (-5.38) ***	1.833 (1.22)	-0.179 (-2.89) ***	116.752 (9.59) ***	0.308
NIR	-54.752 (-6.31) ***	3.155 (2.06) **	0.114 (1.88) *	121.160 (9.61) ***	0.389
OIR	-55.853 (-5.87) ***	2.881 (1.71) *	0.115 (1.88) *	130.615 (9.37) ***	0373
Cost measures					
OER	13.878 (6.15) ***	-0.994 (-2.71) ***	0.780 (17.38) ***	-11.034 (-3.83) ***	0.610
EFR	5.639 (4.49) ***	-0.284 (-1.25)	0.808 (17.39) ***	-5.851 (-3.36) ***	0.614
FCR	116.708 (9.74) ***	-1.962 (-1.16)	0.103 (1.62)	-120.571 (-8.56) ***	0.327
RER	144.361 (11.36) ***	-2.881 (-1.71) *	0.115 (1.88) *	-130.615 (-9.37) ***	0.373
Growth measures					
GRS	-7.018 (-1.00)	-0.153 (-0.12)	0.451 (7.76) ***	30.928 (2.99) ***	0.283
GRNI	-113.569 (-0.18)	-74.337 (-0.65)	-0.058 (-0.83)	1268.897 (1.40)	0.000
GROI	-694.516 (-1.75) *	22.813 (0.32)	-0.051 (-0.73)	1385.989 (2.44) ***	0.017
GRRO	-0.631 (-1.11)	-0.080 (-0.77)	-0.377 (-5.71) ***	3.080 (3.76) ***	0.161
ps: the values in parentheses are t-value; *, ** and *** represent the significant level 0.1, 0.05 and 0.01 respectively.					

Taiwan government initiated a number of institutional changes, including the allowance for setting up the new financial institutions, since 1989. The empirical period of this paper is from 1995 to 2005. Due to the increasing number of banks, the competition was intensive and cruel. Some banks survived but some failed. Our sample contains all the banks whose data are available. So the results are robust not only for the banks with superior performance but also for the whole banking industry.

For the multiple-national banks which want to penetrate an emerging economy, for example China, these banks still have to struggle hard to maintain the competitive edges. Because these banks have not built up a complete branch network nationwide to compete with domestic banks. From our study, non-innovative technology is low-risk and positive for profitability and cost-saving. Therefore, taking advantage of IT, such as the ATMs, may be the best alternative at this stage.

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