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**Policy Analysis Unit (PAU)**

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**Innovative Technology and Bank Profitability: The Bangladesh  
Experience**

**Mohammad Mizanur Rahman**

**December 2007**

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# **Innovative Technology and Bank Profitability: The Bangladesh Experience**

Mohammad Mizanur Rahman\*

December 2007

## **Abstract**

The paper provides evidence on and implications of adopting innovative technology in banking activities in Bangladesh. It also gives a detailed account on the present status and trends in offering innovative products and services by the country's banking sector. The study uses six alternative methods of dividing the banks into two different groups relating to technology adoption, namely adopters and non-adopters. This study uses bank's ROA, ROE, non-interest income growth, interest income growth, total income growth, non-interest expense growth, interest expense growth, total expense growth, deposit growth, loans and advances growth, and NPL growth as performance indicators and shows that the adopters outperform the non-adopters in terms of most of these indicators. One of the important findings of the study is that the performance of the technology-adopters improves as they gain maturity in adopting innovative technology. The result, however, is applicable when all PCBs, FCBs and a bank of SBs are considered to form the technology-adopter group, but the result becomes atypical when NCBs and SBs are also considered with PCBs and FCBs in forming the group.

Keywords: Innovative technology in banking, Banks' profitability, Bangladesh.

JEL Classification: G00, G20, G21

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## **1. Introduction**

Technological innovations and its use in banking activities have been revolutionizing the banking industry all over the world though it is a relatively new phenomenon in Bangladesh. Many countries in the world are now in the state of performing most of their banking activities even being at home through internet while the banks' clients in Bangladesh mostly stay in the long queue for performing their daily banking business. Technology has brought momentum in banking activities through saving time and smoothing the transactions. Recently, it is also attracting the customers and gaining popularity among the traditional banks in Bangladesh. The step toward modern and innovative banking in Bangladesh is likely to smoothen the way to accelerate internet banking within a short time. The increasing trend in the number of users of modern and innovative technology driven products and services offered by different categories of banks reveal the fact that paper based and time consuming traditional banking is gradually being replaced by modern and innovative banking. When the banking system in Bangladesh is engaged in adopting technology driven products and services in recent years, the banks in the advanced world are flourishing different forms of internet banking services. Since the commercial banks in Bangladesh as elsewhere run their business mainly for earning profits, it is important for them to evaluate the profitability of technology driven banking. Obviously, the banks will be encouraged to adopt innovative technology driven products and services if these are found to be cost effective, profitable, and are considered more convenient to the customers.

Technological innovations are taking place in the global banking sector since the 1960s. The First National City Bank of New York (Citicorp) introduced an instrument named the first effective negotiable certificate of deposit (CD) in February 1961. At that time, this was considered as a banking innovation. The following innovations like liability management and numerous financial and technological innovations occurred prior to the 1970s. During the 1980s and early 1990s, a great number of innovations such as merger, consolidations, and failures occurred. Electronic fund transfer system (EFTS or EFT systems) was the preliminary form of technological innovation in the banking sector. The fundamental components of EFTS are automated teller machine (ATMs), point of sale (POS) terminals, and automated clearing houses (ACHs).

Over the last decades, computer technology has substantially transformed the banking industry. The wide distribution of *automated teller machines* (ATMs) by the mid-1980s gave the customers 24-hour access to cash and account information. On-line banking through the Internet and banking through automated phone systems now allow for electronic payment of bills, money transfers, and loan applications without entering a bank branch.<sup>1</sup>

Since the last decade, the introduction of innovative products and services, such as debit cards, credit cards, use of ATMs, transferring fund through ware services, and on-line banking facilities have emerged as an important and new strategy for the banks to attract customers in Bangladesh. It is an established fact that technology driven banking is more convenient and time saving, and hence, is popular with the customers. Therefore, every year traditional banks are coming forward with more and more technology driven products and services for their customers. On the basis of a survey, it is seen that foreign commercial banks (FCBs) have played the pioneering role in adopting modern technology in daily banking activities during the early 1990s in Bangladesh whereas the private commercial banks (PCBs) and the nationalized commercial banks (NCBs) came forward with such services in a limited scale during the late 1990s.<sup>2</sup> Moreover, it is also observed that the banking industry as a whole, except for the four specialized banks (SBs), rushed in offering several new technologies in banking during the middle of the current decade.

The present study has been undertaken primarily to evaluate the impact of adopting innovative technology on the performance of the banking sector in Bangladesh. This is a relatively unexplored area in Bangladesh since most of the earlier studies on technological innovations and its use in traditional banking activities focused on banking software, hardware related risk factors, and associated problems in technology driven banking. This paper provides the evidence on and the implications for adopting innovative technology in the banking sector in Bangladesh along with the details on the present

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<sup>1</sup> For details, see Munn 1983, Klebaner 1990, Schweikart 1990.

<sup>2</sup> The survey was conducted by the author in 2007 on all scheduled banks in Bangladesh using a structured questionnaire. The survey collected detailed information on adoption of innovative technology in banking including information on year wise adoption of specific technology driven products and services, trends in the number of clients, and volume of transactions against these products and services during 1998-2006.

status of offering such innovative technology driven products and services by the country's traditional banks in relation to their performance and associated risks.

The paper is organized in six sections. After this brief introduction, Section 2 provides a review of several empirical studies on measuring the impact of introducing innovative technologies on profitability and other key parameters in the banking sector in different countries. Section 3 describes the methodology and explains the data used in the present study while Section 4 explains the present status and trends in adoption of technology driven products and services in the banking sector of Bangladesh. Section 5 summarizes the empirical findings of the present study. Finally, the conclusions and policy implications are given in Section 6.

## **2. Impact of Technological Innovations on Bank Profitability: Some Empirical Evidence**

Although technological innovation and its use in banking activities is an important advancement in the banking industry, there exist only few studies on measuring the impact of such technological transformation on profitability and other important parameters of banks' performance. Using US banks that offer internet banking, Egland et. al. (1998) analyzed their structure and performance characteristics. Their results, however, reported no significant value addition on the performance of the group of banks offering internet activities compared with the group that did not offer such services.

In a study on Italian banks, Ciciretti et al. (2008) investigated the value addition of internet activities over the traditional banking system. The study traced the experience of Italian banks over a period covering 1993 to 2001. Their results showed a strong and significant association between adoption of internet banking by traditional banks and their profitability. They also found that this positive relationship is significant under different assumptions and definitions of "internet" banking activity.

On the other hand, Furst et. al. (2000, 2002) and Sullivan (2000) reported mixed results. In the case of profitability, their studies reported no significant difference between internet and non-internet banks. Moreover, the former study found that non interest expenses are higher for small (under \$100 million in assets) internet banks compared with non internet banks. Furthermore, the return on equity was lower for small internet

banks but was higher for larger internet banks compared with their non internet counterparts.

In another study on the US banking market, Carlson et. al. (2001) examined the association between internet banking and profitability. They also tested the relationship between more experienced internet banks and the new ones and reached the conclusion that internet banking did not have any independent impact on bank profitability. The studies both by Sullivan (2000) and Furst et. al. (2000) found that newly chartered internet banks earned lower profits than newly chartered non internet banks. Jeevan (2000) observes that the internet enables the banks to offer low cost, and high value added financial services.

In his study, Rahman (2003) provides statistics on the use of electronic devices in banking activities of Bangladesh from which it is shown that the initial cost of on line banking may be high, but it can be recovered within a year. This indicates that the introduction of electronic banking is profitable for the banks. Citing the example of the US, he also argues that the cost per transaction in on line banking is 43 percent lower than that of branch banking in Bangladesh. From the point of view of profitability, his study supports the assertion that the adoption of technology driven products and services in banking activities helps in generating higher profit.

This brief review, as presented above, shows that available studies focus mainly on the impact of adoption of internet banking on the performance of traditional banks while the broader issues relating to innovative technology and bank profitability remain partly addressed. This paper examines the relationship between the adoption of innovative technology and bank profitability in a comprehensive manner in the context Bangladesh.

### **3. Methodology and Data**

The study follows six alternative methods, following the initiatives by Ciciretti et al (2008) to investigate the marginal impact of adopting innovative technology on bank performance.

The primary data set used in the present study has been collected by the author through a survey on all scheduled banks in Bangladesh. The survey collected detailed information on technology driven products and services including data on year wise adoption of

specific technology driven products and services by the traditional banks and trends in the number of clients and volume of transactions against these products and services during 1998-2006.

The data on bank performance are collected from the secondary source (Department of Offsite Supervision, Bangladesh Bank) covering information on net income after tax and provision (NIAPT) of individual banks, total assets, total equity, interest incomes, non interest incomes, total incomes, interest expenses, non interest expenses, total expenses, deposits, total loans and advances, non performing loans (NPL), and other parameters during 2005-2006.

The changes in profitability and other measures of performance were computed using yearly data for two calendar years, 2005 and 2006, separately for technology adopting and non-adopting banks so that their performance over different maturity in offering innovative technology may be traced and evaluated.

### **Performance Indicators**

The study has been conducted using variables that indicate profitability as well as performance and risk of a bank, such as return on asset (ROA), return on equity (ROE), interest income, interest expense, non-interest income, non-interest expense, total income, total expense, deposits, loans and advances, and non performing loan (NPL). Since these indicators have impact on bank profitability, their growth patterns have also been evaluated as a part of measuring bank efficiency.

### **Defining the Study Framework**

In the present study, the scheduled banks in Bangladesh have been categorized into two broad groups; namely technology adopting group (TAG) and technology non adopting group (TNG). The TAG includes those banks that have adopted at least two or more innovative technology driven products and services, such as debit card, credit card, automated teller machine (ATM), point of sales (POS), any branch banking through individual bank on line network, internet, and SWIFT by 2005, and have gained at least one year maturity in offering such services by 2006. The TNG, on the other hand,

comprises of those banks that have adopted no or only one innovative product and service by 2005.

In dividing the banks into TAG and TNG, it is found that 33 banks (three NCBs, one SB, 24 PCBs, and five FCBs) out of 48 banks belong to TAG while the rest 15 banks (one NCB, four SBs, six PCBs, and four FCBs) belong to TNG. For the study, each category of banks (NCBs, SBs, PCBs, and FCBs) is evaluated separately so that these are divided into TAG and TNG and then the performance of these two groups is compared. Along with the above four alternative methods, two other classifications are also included: (i) dividing the banks into TAG and TNG considering 40 selected banks (30 PCBs, nine FCBs, and one from SBs), and (ii) dividing the banks into TAG and TNG considering all scheduled banks. The main reason for applying these separate alternative methods is to ensure consistency in forming groups of banks so that any bias due to unusual performance of individual banks is reduced. Besides, one of the important reasons for selecting 40 banks (excluding four NCBs and four SBs from the total of 48 scheduled banks) in one classification is that the performance of the excluded banks is not satisfactory due to a number of reasons, such as huge classified loans, provision short fall, and zero or low net income after tax. Among the included 40 banks, 30 banks (one SB, 24 PCBs, and five FCBs) belong to TAG while the remaining 10 banks (six PCBs and four FCBs) belong to TNG in which the technology adopting banks are mostly consistent in overall banking behavior.

Since the banks are observed to adopt innovative technology during different years, the TAG has been divided into different sub groups based on maturity gained in offering innovative technology driven products and services since adoption. These are defined in the study as  $Y_{+1}$ ,  $Y_{+2}$ ,  $Y_{+3}$  and so on.<sup>3</sup>

One of the hypotheses of the present study is that the performance variables will improve and the risk factors will decline with the increase of years since the adoption of technology. For the purpose, the study examined whether the profitability indicators of

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<sup>3</sup>  $Y_{+1}$  refers adoption + year 1 indicating the group of banks that have adopted at least two or more innovative technology driven products and services in 2005 and have gained one year maturity in offering such services by 2006. Similarly,  $Y_{+2}$  refers adoption + year 2 indicating that the bank group adopted the services in 2004 and has gained two year maturity in offering the services by 2006. Similar definitions follow for  $Y_{+3}$  others.

banks, such as ROA, ROE and the income variables such as non interest income growth, interest income growth, total income growth increase and the risk factors of banks such as non interest expense growth, interest expense growth, non performing loan growth decline as the banks gain maturity in offering innovative technology driven products and services. While forming groups for the SBs, one bank is found to belong to TAG and the remaining four SBs belong to TNG. In the case of PCBs, 24 banks offer innovative technology and have gained one year maturity while the number of banks stood at 10 with four year maturity and two with six year maturity while the TNG consists of six PCBs. Among the technology adopting banks in FCBs, five belong to the  $Y_{+1}$  group, four to  $Y_{+3}$  group, and three banks to the  $Y_{+6}$  group while the TNG consists of four FCBs.

However, it is worth mentioning that the four NCBs own 35 percent of total bank assets whereas 30 PCBs own 50 percent, nine FCBs have 13 percent and five SBs own only 2 percent. Despite the fact that the NCBs are large in respect of shares in assets and number of branches, they could cover only around 16 percent of their branches under computerization by 2006 while the PCBs and FCBs brought nearly 99 percent and 100 percent of their branches respectively under computerization. The performance of four SBs in computerization is unsatisfactory with only 4 percent of the branches computerized by the end of 2006 (Table 2).

Moreover, the NCBs and SBs could not as yet adopt credit cards, tele banking, and any branch banking facility. Considering these aspects, 40 banks (30 PCBs, nine FCBs, and one SB) are considered in forming TAG and TNG in which 30 banks belong to TAG and the remaining 10 banks belong to TNG based on the criteria as stated earlier. On the basis of maturity in adopting innovative technology, it is found that  $Y_{+1}$  includes 30 banks (one SB, 24 PCBs, and five FCBs),  $Y_{+4}$  includes 13 banks (10 PCBs and three FCBs) and  $Y_{+6}$  includes five banks (two PCBs and three FCBs).

Finally, the TAG and TNG are formed considering all scheduled banks (48 banks) in which 33 banks (three NCBs, one SB, 24 PCBs, five FCBs) belong to TAG and the rest 15 banks (one NCB, four SBs, six PCBs, and four FCBs) belong to TNG. Of the banks belonging to TAG, 33 banks have gained one year maturity, 16 banks (three NCBs, 10 PCBs, and three FCBs) have gained 4 year maturity and six banks (one NCB, two PCBs

and 3 FCBs) have gained 6 years maturity in adopting innovative technology driven products and services.

#### **4. Adoption of Innovative Technology in the Banking Sector**

The existing modern and innovative technology driven products and services offered by the banking system in Bangladesh includes debit card, credit card, automated teller machine (ATM) cards such as Master Card, Visa Card, Q-cash Card, point of sales (POS), on line service, tele banking, internet banking, society for worldwide inter bank financial telecommunication (SWIFT), and Reuter. The debit card allows its holder 24-hour cash access to his/her savings or current account through ATM and POS terminals and hence its holder enjoys cash withdrawal facility round the clock. Besides, the credit card allows its holder 24-hour cash access within the sanctioned limit to his/her credit account through ATM, POS, merchant shop window, and payment counter. ATM functions as a cash counter of a bank branch such that it allows all types of debit card, credit card, Q-cash, Visa, and other cards for making transactions. Moreover, POS functions as a receiving desk of cash counter of a bank branch that allows all types of debit card, credit card, Q-cash,, Visa and other cards for making payment against products purchased or services rendered at different merchant locations. The on line service provides any branch banking facilities to its customers through respective bank online network. Tele banking serves the customers through providing information on account balance, banking products or services, ATM card activation, and other services. Popular current trend of internet banking products and functions are: account balance enquiry, fund transfer among the accounts of the same customer, opening or modifying of term deposit account and similar services. SWIFT is an international network for the bank community that provides instant message transmission services to its member banks. Reuter provides information services regarding market rate, commodity rate, market news and views, and other aspects. <sup>4</sup>

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<sup>4</sup> Definition and functions of existing innovative technology driven products and services offered by the banking system in Bangladesh are given in Appendix.

## Trends in Technology Adoption

Table 1 shows the trend in technology adoption in the country's banking sector over the period 1998 to 2006.

**Table 1: Adoption Frequency of Technology in Banking, 1998-2006**

No. of banks adopting modern and innovative technology driven products and services											
Year	Bank type	No.	Cr. card	Dr. card	ATM	POS	Internet	Tele banking	On-line	SWIFT	Reuter
1998	NCBs	4	0	0	0	0	0	0	0	0	3
	DFIs	5	0	0	0	0	0	0	0	0	0
	PCBs	30	1	0	0	0	0	0	0	1	2
	FCBs	10	1	0	1	1	0	0	2	3	2
	Total	49	2	0	1	1	0	0	2	4	7
1999	NCBs	4	0	1	0	1	0	0	0	0	3
	DFIs	5	0	0	0	0	0	0	0	1	0
	PCBs	30	2	0	0	1	0	1	0	7	5
	FCBs	10	1	0	2	1	0	0	2	3	2
	Total	49	3	1	2	3	0	1	2	11	10
2000	NCBs	4	0	1	0	1	0	0	0	1	3
	DFIs	5	0	0	0	0	0	0	0	1	0
	PCBs	30	2	0	0	1	0	1	1	11	6
	FCBs	10	1	0	2	1	0	0	3	4	2
	Total	49	3	1	2	3	0	1	4	17	11
2001	NCBs	4	0	1	0	1	1	0	0	2	3
	DFIs	5	0	0	0	0	0	0	0	1	0
	PCBs	30	3	3	5	2	0	1	3	16	9
	FCBs	10	1	0	2	1	0	1	3	4	3
	Total	49	4	4	7	4	1	2	6	23	15
2002	NCBs	4	0	3	2	2	1	0	0	3	3
	DFIs	5	0	0	0	0	0	0	0	1	1
	PCBs	30	3	7	8	2	1	1	4	21	10
	FCBs	10	1	0	2	1	1	1	3	5	3
	Total	49	4	10	12	5	3	2	7	30	17
2003	NCBs	4	0	3	2	2	1	0	0	3	3
	DFIs	5	0	0	0	0	0	0	0	2	1
	PCBs	30	3	8	9	2	1	2	12	25	14
	FCBs	10	1	0	3	1	1	1	4	6	4
	Total	49	4	11	14	5	3	3	16	36	22
2004	NCBs	4	0	3	2	2	1	0	0	4	3
	DFIs	5	0	0	0	0	0	0	0	2	1
	PCBs	30	7	11	12	4	3	2	15	28	16
	FCBs	10	1	1	4	1	3	2	4	6	4
	Total	49	8	15	18	7	7	4	19	40	24
2005	NCBs	4	0	3	2	2	1	0	0	4	3
	DFIs	5	0	0	1	0	0	0	0	2	1
	PCBs	30	11	13	15	7	3	2	18	29	16
	FCBs	9	1	2	4	1	3	2	4	6	5
	Total	48	12	18	22	10	7	4	22	41	25
2006	NCBs	4	0	3	3	2	1	0	0	4	3
	DFIs	5	0	0	1	0	0	0	0	2	1
	PCBs	30	14	17	17	7	3	2	22	29	16
	FCBs	9	1	2	5	1	3	2	7	8	5
	Total	48	15	22	26	10	7	4	29	43	25

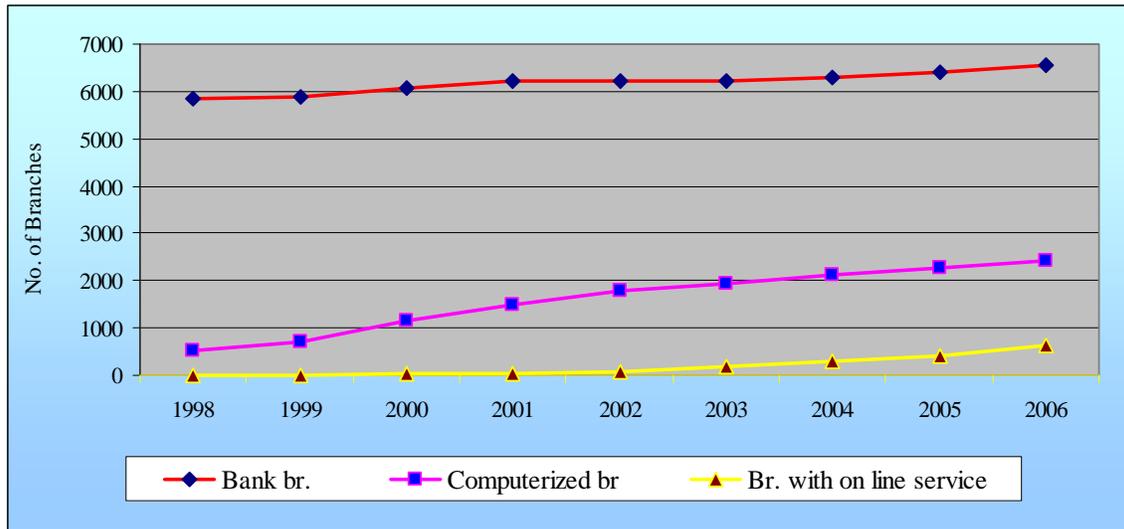
Note: 1. Online denotes any-branch-banking facility through online connectivity which is offered by individual bank through its respective online network. Inter bank on line network is yet to be established.

2. Internet column refers to number of banks providing some limited services through internet. Remote transactions facilities over internet are yet to develop.

Source: Author's survey in 2007

It is evident from Table 1 that, out of different innovative technology driven products and services, significant response among the banks is observed in adopting ATM, on line, and SWIFT during the 1998-2006 period. More specifically, the number of banks offering credit cards increased from 2 to 15, debit cards from nil to 22, ATM service from 1 to 26, POS service from 1 to 10, internet service from nil to 7, tele banking service from nil to 4, any branch banking through individual bank on line network from 2 to 29, SWIFT service from 4 to 43, and Reuter service from 7 to 25. The survey on the commercial banks shows that while only 2 out of 49 banks adopted at least any two or more technology driven products and services in 1998, the number reached 33 out of 48 banks by the end of 2006.<sup>5</sup>

**Figure 1: Bank Branches, Computerized Branches, and Branches providing any-Branch-banking Facility under On line Network**



Source: Author's survey in 2007

**Table 2: Computerization of Bank Branches by Categories, 1998-2006**

(in percent)

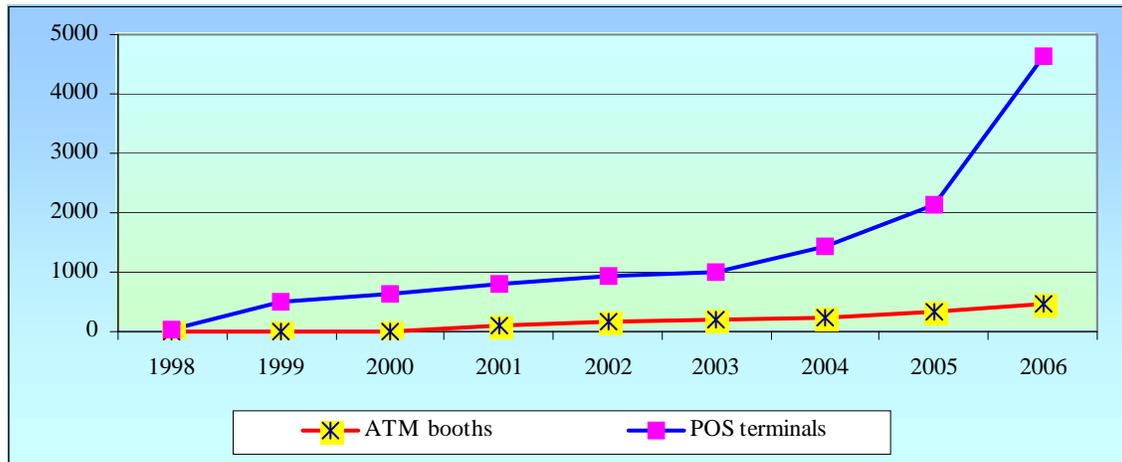
	1998	1999	2000	2001	2002	2003	2004	2005	2006
NCBs	2.65	4.14	7.02	8.35	10.09	11.89	14.43	16.12	16.38
SBs	1.96	2.04	2.18	2.06	4.20	4.20	4.39	4.35	4.38
PCBs	38.54	46.32	67.67	85.86	95.67	97.76	98.45	98.90	98.99
FCBs	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total	9.20	11.74	18.95	23.91	28.61	31.10	33.50	35.42	36.95

Source: Author's survey in 2007

<sup>5</sup> The total number of banks declined from 49 to 48 due to the merger of the American Express Bank, a FCB, with the Standard Chartered Bank, another FCB in Bangladesh in 2005.

Figure 1 and Table 2 together provide the overall picture of computerization in the banking system of Bangladesh during 1998-2006. In 1998, out of 5,860 branches (NCBs 3,619; SBs 1,173; PCBs 1,056; and FCBs 13), only 539 branches (NCBs 96; SBs 23; PCBs 407; and FCBs 13) were computerized, and only two FCBs were providing any branch banking facility connecting a total of six branches under their respective on line network. By the end of 2006, a significant improvement in computerization can be observed especially by the PCBs. Out of 6,565 branches (NCBs 3,388; SBs 1,347; PCBs 1,776; and FCBs 54) in 2006, a total of 2,426 branches (NCBs 555; SBs 59; PCBs 1,758; and FCBs 54) were computerized of which 651 branches of 22 PCBs, and 7 FCBs were providing any branch banking facility under respective bank on line network.

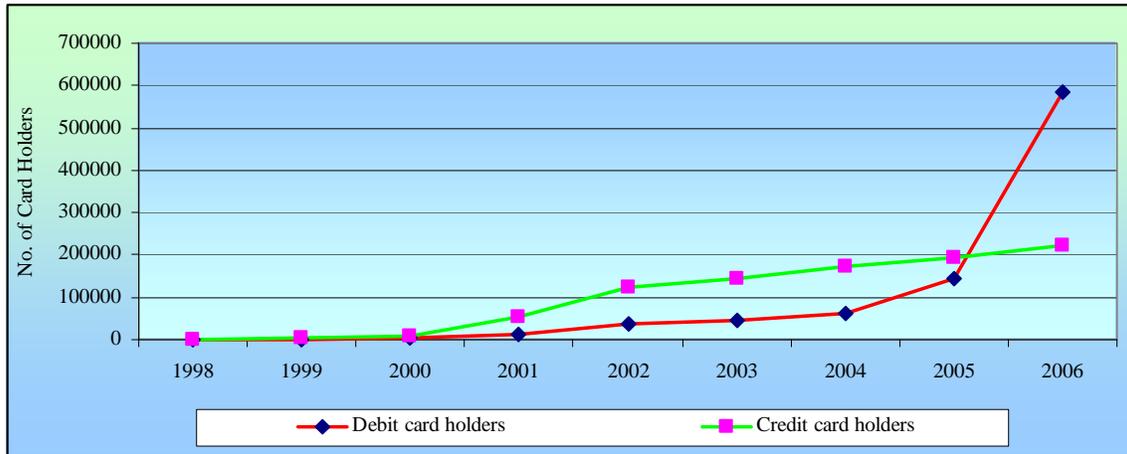
**Figure 2: ATM Booths and POS Terminals in the Banking System, 1998-2006**



Source: Author's survey in 2007

One FCB introduced ATM and POS services for the first time in Bangladesh in 1992 and 1997 respectively. By the end of 1998, the bank has set up five ATM booths and 20 POS terminals in different locations of Dhaka city. Other categories of banks, such as PCBs, NCBs, and one SB gradually adopted both the services as a part of market competition in offering better customer services. Figure 2 shows that growth rate in adoption of POS terminals was higher compared with ATM booths during the 1998-2006 period. By the end of 2006, the number of ATM booths and POS terminals stood at 478 and 4,647 respectively covering important merchant outlets in six divisional cities and some other important district towns in Bangladesh.

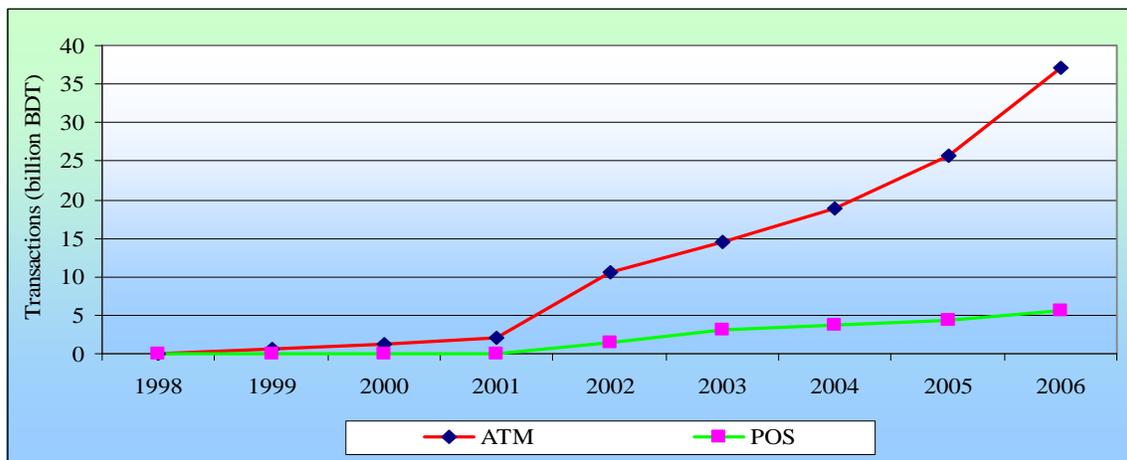
**Figure 3: Number of Clients holding Debit and Credit Cards, 1998-2006**



Source: Author's survey in 2007

Debit card, popularly termed as plastic money or electronic money, was introduced by one NCB in 1999 and by the end of the year the number of customers stood at 2,014. Similarly, Credit card came into Bangladesh's market in 1997 through one PCB and one FCB; and the total number of customers stood at 1,607 by the end of 1998. Figure 3 shows that the number of debit card and credit card holders were growing moderately during 1998-2006 period except for the period of 2005 and 2006 when the number of debit card holders gave a big jump and stood at 585,465 by the end of 2006. Besides, the number of credit card holders is recorded at 221,100 at of end December 2006.

**Figure 4: Volume of Transactions through ATM and POS, 1998-2006**



Source: Author's survey in 2007

The total volume of transactions through ATM is recorded at BDT 0.70 billion during 1999, growing moderately up to 2001, and recording a transaction of BDT 2.11 billion at the end December 2001. Since 2001, a significant increase in transactions through ATM is observed showing a transaction volume of BDT 37.19 billion by the end of 2006. Besides, using the POS terminals, the customers made payments of BDT 0.02 billion during 1999 against their purchase of goods and services which increased to BDT 5.58 billion by the end of 2006. It is evident from Figure 4 that a significant growth in transactions through ATM is observed relative to POS terminals during 1998-2006.

## 5. Results of Profitability Analysis

Table 3 reports the numerical values of different performance indicators of TAG and TNG among the NCBs. The ROA and ROE for both the TAG ( $Y_{+1}$  to  $Y_{+6}$  groups) and TNG are zero (see Appendix Table A.1). These are due to zero net income after tax (NIAPT) followed by provision shortfall of all banks in these groups.

**Table 3 : Changes in Performance Indicators of Technology Adopting and Non Adopting Groups of NCBs in 2006**

Variable/ Ratios (Growth)		(in percent)										
		ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG	$Y_{+1}$ 3 NCBs	0.00	0.00	44.75	9.98	18.06	12.88	22.71	19.58	1.34	7.33	11.81
	$Y_{+6}$ 1 NCB	0.00	0.00	95.50	3.50	22.81	9.17	28.59	21.22	10.24	11.14	25.88
TNG: 1 NCB		0.00	0.00	103.58	-58.40	-49.01	13.55	-58.23	-47.18	-0.96	1.99	51.21

Note : 1. The variables used in the table are Return on Asset (ROA), Return on Equity (ROE), Non Interest Income Growth (NIIGR), Interest Income Growth (IIGR), Total Income Growth (TIGR), , Non-Interest Expense Growth (NIEGR), Interest Expense Growth (IEGR), Total Expense Growth (TEGR), Deposit Growth (DGR), Loans and Advances Growth (L&AGR), and Non Performing Loan Growth (NPLGR)

2.  $Y_{+1}$  refer adoption + year 1 meaning that the bank group gained maturity of one year since adoption of innovative technology driven products and services while  $Y_{+6}$  refers adoption + year 6 meaning the same for 6 years.

3. Percentage of Return on Asset (ROA) = (Net Income after Tax and Provision / Total Asset) \* 100. Similarly, percentage of Return on Equity (ROE) = (Net Income after Tax and Provision / Total Capital and Reserve) \* 100. Since Net Income after Tax and Provision found zero for each of the NCBs in 2006 that results in zero ROA and ROE in Table 3.

Source : Author's calculations.

The NIIGR for the TAG ( $Y_{+1}$  and  $Y_{+6}$  groups) increased from 44.8 percent to 95.5 percent while TIGR increased from 18.1 percent to 22.8 percent, DGR increased from 1.3 to 10.2 percent, and L & AGR increased from 7.3 percent to 11.1 percent while NIEGR

declined from 12.9 percent to 9.2 percent (see Table 3). The above indicates that the banks in the group have improved their performance as well as reduced the risk factors excepting NPLGR, as the banks gained maturity in offering innovative technology in their activities. In comparing the performance between TAG and TNG, Table 3 shows that the TAG outperforms the TNG in case of performance measures, such as IIGR, TIGR, DGR, and L & AGR as well as reducing risk factors such as NIEGR

Of the five SBs in Bangladesh, one SB is found to have adopted innovative technology as mentioned earlier while the remaining four SBs have not adopted any of such products and services. The comparative performance between the technology adopting bank and the TNG is shown in Table 4. The ROA and ROE for the technology adopting bank is 1.9 percent and 22.3 percent respectively which are significantly higher than those of TNG (Table 4 and Appendix Table B.1). Besides, the analysis shows that the technology adopting bank reports significantly higher earnings against all considered indicators, such as NIIGR, IIGR, TIGR compared with those of TNG. The difference is more significant in case of NIIGR where the technology adopting bank reports 107.9 percent growth which is significantly higher than -0.1 percent growth by the TNG. But, the performance of technology adopting bank is not positive in reducing the risk factors compared with TNG such that NPLGR for TNG is -0.1 which is lower than 0.7 of the technology adopting bank. Besides, the technology adopting bank shows a lower performance in case of NIEGR where the bank reports 40.4 percent growth compared with -0.02 percent by TNG. The cause of this higher growth in expenditure for technology adopting bank may be due to the cost of adopting technology and higher employment cost related to technology based services. Thus evaluating the result in Table 4, it may be concluded that innovative technology in banking in Bangladesh add value to banks' performance.

**Table 4 : Changes in Performance Indicators of Technology Adopting and Non Adopting Groups of SBs in 2006**

(in percent)											
Variable/ Ratios (Growth)	ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG: Y <sub>+1</sub> 1SB	1.87	22.25	107.91	17.23	28.81	40.40	33.73	35.38	3.72	-46.68	0.69
TNG: 4 SBs	-0.0002	-0.001	-0.10	0.16	0.12	-0.02	0.29	0.14	0.23	0.06	-0.06

Note : Since technology adopted group (TAG) consists of one specialized bank (SB), the result found for Y<sub>+1</sub> to Y<sub>+6</sub> groups of TAG remains unchanged and hence to avoid repetition, the results found for Y<sub>+2</sub> to Y<sub>+6</sub> are not shown.

Source : Author's calculation.

The performance of TAG and TNG, examined for the PCBs, is shown in Table 5. The study found that ROA and ROE were 1.2 percent and 16.7 percent respectively for  $Y_{+1}$  of TAG, which increased to 1.3 percent and 19.4 percent respectively for  $Y_{+4}$  and further to 1.5 percent and 21.7 percent for  $Y_{+6}$ .<sup>6</sup> Besides, IIGR, TIGR, DGR, and L & AGR also increased from  $Y_{+1}$  to  $Y_{+6}$ . Hence, it is evident (see Table 5 and Appendix Table C.1) that ROA and ROE, two important measures of bank's profitability, increased as the banks gained maturity in offering innovative technology since the adoption of such services. Similarly, IIGR, TIGR, DGR, and L & AGR, the other performance measures of the banks improved over the period. On the other hand, in reducing the risk factors such as TEGR and NPLGR, the TAG improved its performance continuously. But the irregular pattern of performance growth against NIEGR may be due to cost of adopting innovative technology in banking activities. However, in comparing the performance between TAG and TNG, it is found that the TAG outperforms the TNG in respect to increasing profitability, reducing risk factors, and increasing other performance measures except NIIGR.

**Table 5 : Changes in Performance Indicators of Technology Adopting and Non Adopting Groups of PCBs in 2006**

Variable/ Ratios (Growth)		(in percent)										
		ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG	$Y_{+1}$ 24 PCBs	1.17	16.69	66.65	31.76	38.72	36.01	41.18	39.82	22.95	28.18	7.00
	$Y_{+4}$ 10 PCBs	1.31	19.41	65.37	32.34	39.57	40.45	37.54	38.34	26.92	29.19	5.93
	$Y_{+6}$ 2 PCBs	1.54	21.65	45.91	41.44	42.76	21.71	47.47	37.63	32.41	32.25	5.44
TNG: 6 PCBs		0.35	5.05	51.55	8.33	17.51	14.53	31.66	26.08	7.79	20.24	58.92

Source : Author's calculations.

Table 6 reports the performance of TAG and TNG for the FCBs. The results show that ROA for the TAG increased from  $Y_{+1}$  to  $Y_{+3}$  but declined in  $Y_{+6}$  (Table 6 and Appendix Table D.1). Since ROA is the ratio of net income after tax and provision (NIAPT) and total asset, the cause of the irregular pattern of ROA between the groups may be due to declining rate of asset size relative to increasing rate of NIAPT while leaving one FCB in

<sup>6</sup>  $Y_{+1}$ ,  $Y_{+4}$ , and  $Y_{+6}$  refer to the bank groups that have adopted at least two or more innovative technology driven products and services in 2005, 2002, and 2000 respectively and have gained maturity of one year, four years, and six years respectively since adoption of such services.

$Y_{+3}$  over  $Y_{+1}$  and for  $Y_{+6}$  over  $Y_{+3}$ . However, the TAG improved its performance in increasing the ROE and reducing the risk factor such that NPLGR declined over the period as the TAG gained maturity in offering innovative technology. The performance of the TAG in improving its efficiency becomes ambiguous due to irregular pattern of NIIGR, TIGR, NIEGR, IEGR, TEGR, DGR, and L & AGR. However, in the case of comparative performance between TAG and TNG, the study shows that the TAG outperforms the TNG in respect of increasing their profitability measures such as ROA, and ROE and reducing the risk factors such as NIEGR, IEGR, TEGR, and NPLGR.

**Table 6: Changes in Performance Indicators of Technology Adopting and Non Adopting Groups of FCBs in 2006**

Variable/ Ratios (Growth)		(in percent)										
		ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG	$Y_{+1}$ 5 FCBs	2.19	24.74	58.11	25.95	33.30	19.99	36.28	28.61	17.65	20.37	-21.00
	$Y_{+3}$ 4 FCBs	2.20	25.75	57.63	20.83	32.22	19.23	32.34	26.01	16.16	19.64	-21.27
	$Y_{+6}$ 3 FCBs	2.18	26.63	61.04	20.62	33.08	19.47	32.68	26.18	16.44	19.75	-21.87
TNG: 4 FCBs		1.84	6.94	81.72	79.47	80.03	114.10	97.47	101.85	82.13	73.43	9.07

Source : Author's calculations.

The performance record of TAG and TNG for selected 40 commercial banks (30 PCBs, nine FCBs, and one SB) is given in Table 7. Out of these 40 banks, 30 banks (24 PCBs, five FCBs, and one SB) belong to TAG and the rest 10 banks (six PCBs, and four FCBs) belong to TNG. In the sub groups of TAG,  $Y_{+1}$  includes 30 banks (24 PCBs, five FCBs, and one SB) while  $Y_{+4}$  and  $Y_{+6}$  include 13 banks (10 PCBs and three FCBs) and five banks (two PCBs and three FCBs) respectively. The study found that ROA and ROE, two important measures of bank's profitability, were 1.4 percent and 18.8 percent respectively for  $Y_{+1}$  which increased to 1.6 percent and 22.0 percent respectively for  $Y_{+4}$ , increasing further to 2.0 percent and 25.3 percent respectively for  $Y_{+6}$ . Hence, it is evident that ROA and ROE increased over the period as the banks gained maturity in offering innovative technology (Table 7 and Appendix Table E.1). On the other hand, in reducing the risk factors such as TEGR and NPLGR, the TAG improved its performance as well. But the irregular pattern of performance improvement against DGR, L & AGR, and other income

and expense variables, somewhat offset the positive impact of innovative technology on banks' performance. However, while comparing the performance between TAG and TNG, the TAG is seen to outperform the TNG in respect of increasing profitability and reducing risk factors except the expense variables.

**Table 7: Changes in Performance Indicators of Technology Adopting and Non Adopting Groups for 40 Selected Banks in 2006**

		(in percent)										
Variable/ Ratios (Growth)		ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG	Y <sub>+1</sub> N=30 (1 SB, 24 PCBs, 5 FCBs)	1.40	18.80	65.39	30.09	37.67	33.40	40.66	38.59	21.66	23.26	5.75
	Y <sub>+4</sub> N=13 (10 PCBs, 3 FCBs)	1.58	22.02	64.02	29.73	37.99	35.07	36.96	36.37	24.55	27.40	3.85
	Y <sub>+6</sub> N=5 (2 PCBs, 3 FCBs)	1.98	25.25	55.14	29.10	36.97	20.53	41.32	32.31	23.00	25.50	-2.96
TNG: N=10 (6 PCBs, 4 FCBs)		0.52	5.68	54.03	13.13	21.93	18.70	35.34	29.97	12.08	23.71	58.47

Source : Author's calculations.

Finally, all scheduled banks are taken in forming TAG and TNG as per the set criteria mentioned earlier. Among the sub groups of TAG, Y<sub>+1</sub> includes 33 banks (three NCBs, one SB, 24 PCBs, and five FCBs), Y<sub>+4</sub> includes 16 banks (three NCBs, 10 PCBs, and three FCBs), and Y<sub>+6</sub> includes six banks (one NCB, two PCBs, and three FCBs) while the TNG includes 15 banks (one NCB, four SBs, six PCBs, and four FCBs). However, the performance of TAG and TNG is shown in Table 8 and Appendix Table F.1. The ROA and ROE were 0.9 percent and 18.5 percent respectively for Y<sub>+1</sub>; ROA declined to 0.8 percent and ROE increased to 21.4 percent for Y<sub>+4</sub> followed by increase of ROA to 1.3 percent and decline of ROE to 21.2 percent for Y<sub>+6</sub>. The main cause of irregular pattern of ROA, ROE, NIIGR, TIGR, DGR, and L & AGR may be the presence of NCBs in forming the groups of different maturities. Since ROA and ROE for the NCBs is zero which impacts on the result found for Y<sub>+4</sub>. If the NCBs are excluded, we see that different groups in TAG raises their performance in respect to almost all the performance measures as they gain maturity in adopting innovative technology. A better performance is also recorded for the TAG in reducing risk factors such that NIEGR and TEGR decrease over the period. Besides, while comparing the performance between TAG and TNG, it is found that the TAG outperforms the TNG in respect to all the performance

measures except the expense variables. The nature of banking among different bank categories is still uneven in Bangladesh and this seems to create impact on bank's performance. Thus the results become atypical when the study is conducted considering all scheduled banks in forming TAG and TNG.

**Table 8: Changes in Performance Indicators of Technology Adopting and Non Adopting Groups for All Scheduled Banks in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE	NIIGR	IIGR	TIGR	NIEGR	IEGR	TEGR	DGR	L & AGR	NPLGR
TAG	Y <sub>+1</sub> N=33 (3 NCBs, 1 SB, 24 PCBs, 5 FCBs)	0.90	18.49	58.72	24.18	31.70	25.82	34.69	32.06	13.07	16.99	10.46
	Y <sub>+4</sub> N=16 (3 NCBs, 10 PCBs, 3 FCBs)	0.83	21.41	55.55	20.83	29.06	24.11	30.07	28.20	11.38	16.53	10.82
	Y <sub>+6</sub> N=6 (1 NCB, 2 PCBs, 3 FCBs)	1.25	21.18	67.02	18.74	31.66	15.88	35.41	27.41	16.72	18.63	20.37
TNG: N=15 (1 NCB, 4 SBs, 6 PCBs, 4 FCBs)		0.29	3.25	56.62	-16.39	-5.33	14.53	-10.87	-4.24	8.51	14.53	30.66

Source : Author's calculations.

## 6. Conclusions and Policy Implications

It is a matter of significant importance to know whether decisions regarding adoption of innovative technology in banking constitute one of the prime factors in determining banks' performance and growth. The present study shows the existence of strong association between banks that have adopted innovative technology in offering banking services and their performance. The findings reveal that there exist some evidence regarding the link between technology adoption by the traditional banks and their profitability. The existence of such positive relationship is found under some assumptions and definitions of innovative technology in banking services such that the banks using at least any two or more of technology driven products and services by the end of 2005 and those that have gained at least one year maturity by 2006 since adoption of such services are considered as technology adopters while the rest of the banks are considered as non adopters. The study finds that the technology adopter group outperforms the non adopter group to some extent in case of all the alternative methods used in the present analysis. Moreover, it is also found that the technology adopting banks increase profitability as well as reduce the risk factors as they gain maturity in offering such services. Another important finding of the study is that the ROA and ROE for the technology adopting

groups in FCBs are greater than those of PCBs which are greater than those of SBs. However, these values for NCBs are found to be zero. It may be mentioned that profitability and other indicators of bank performance depend, in addition to adoption of innovative technology, on several other factors affecting the costs and returns of the banks. The methodology adopted in the present study does not separate out these effects and hence the conclusions need to be interpreted with caution.

The findings of the study have important policy implications for efficiently managing the financial institutions, especially the commercial banks. The study shows that the adoption of innovative technology impacts positively on banks' performance indicating that the managers of such institutions need to put emphasis on adoption and diversification of such services. In particular, the NCBs should take appropriate actions for increasing their coverage in offering innovative technology driven services with a view to increasing their performance and raising their market competitiveness. The Bangladesh Bank, being the regulator of the financial system, can play an important role through taking necessary measures to expedite the initiatives of the traditional banks in adopting such innovative technology driven products and services in their banking activities.

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## Appendix

**Chart: 1: Definitions and Functions of Innovative Banking Technology in Bangladesh**

Product/Service	Definition	Functions
Debit Card	A special plastic card that is encoded with information on a magnetic strip linked with deposit accounts with access to ATM or POS terminal	24-hours cash access to customer's savings or current account only through ATM and POS terminals, balance enquiry, mini statement printing in ATM, cash withdrawal from ATM, fast cash, fund transfer to linked accounts of respective customer, PIN change, cheque book request, utility bills payment, prepaid card, cash deposit, cheque deposit, purchase of goods and services through POS terminal, transaction details, etc
Credit Card	A special plastic card that is encoded with information on a magnetic strip linked with credit accounts with access to ATM or POS terminal located at merchant outlet, restaurant, 5 star hotels, hospitals etc	24-hours cash access within the sanctioned limit to customer's credit account through ATM, POS, merchant shop window, and payment counter, making payment to merchant against purchase of goods and services, availing cash advances, withdrawal of cash from ATM, SMS banking, I banking, E statements, auto bills, pay insurance coverage, rewards program, card cheque, etc
ATM	An electronic device used by bank customers to process account transactions. Typically, a user inserts into the ATM a special plastic card that is encoded with information on a magnetic strip. The strip contains an identification code transmitted to the bank's central computer by modem. Basically, ATM functions as a cash counter of a bank branch	Allows all types of debit card, credit cards, Q-cash card, visa card etc for making transactions, allow all visa card holders to withdraw cash, balance inquiry, 24-hours cash withdrawal facilities using debit/ credit cards, fast cash, fund transfer, PIN change, mini statement, statement request, cheque book request, utility bill payment, prepaid card, cash deposit and cheque deposit etc.
POS	An electronic device having features to identify the special plastic card that is encoded with information on a magnetic strip. Actually, the device functions as a receiving desk of cash counter of a bank branch	Allows all types of debit card, credit cards, Q-cash card, visa card etc for making transactions, provides a number of facilities such as, payment for products purchased or services rendered at different merchant locations using debit/ credit cards, return of goods and services etc
On line	A wide area network (WAN) connecting branches of individual bank, which provides	Provides transactional facility through any branch under the respective bank online network, payment against pay order or pay order encashment from any branch, demand draft encashment from any branch,

Product/ Service	Definition	Functions
	any-branch-banking facilities to its customers	opening or redemption of FDR from any branch, remote fund transfer, remote cash withdrawal, remote account statement, clearing for any branch a/c, remote balance inquiry, sweep-in, sweep-out, opening L/C from any branch, loan repayment to any branch, deposit and withdrawal facility to and from any branch of individual bank under its own online network etc
Tele banking	Tele banking refers to the services provided through phone that requires the customers to dial a particular telephone number to have access to an account which provides several options of services	Detail account information, balance inquiry, information about products or services, ATM card activation, chequebook related service, bills payment, credit card service etc
Internet banking	Internet banking refers to the use of the internet as a remote delivery channel for banking services. It is nothing but the WWW through which banks can reach to their customers directly with no intermediaries. It permits the customer to conduct transactions from any terminal with access to the internet.	Account balance enquiry, fund transfer among the accounts of same customer, Opening or modify of term deposit account, cheque book or pay order request, exchange rate or interest rate enquiry, bills payment, account summary, account details, account activity, standing instructions, loan repayment, loan information, statement request, ,cheque status enquiry, stop payment cheque, refill prepaid card, password change, L/C application, bank guarantee application, lost card (debit/credit) reporting, pay credit card dues, view credit card statement or check balance etc.
SWIFT	SWIFT is a Belgium based international network for the bank community which the commercial banks use widely for international business	Provides instant message transmission services to its member banks, sending and receiving fund transfer message both outward and inward, receiving NOSTRO account statement and correspondence between banks, transmits remittance related messages, transmitting payment instructions, transmit letter of credit (L/C) related messages such as, L/C issuance, advising, subsequent amendments, negotiations, add confirmations and reimbursements.
Reuter	A message providing electronic device linked with international financial market	Provides information services regarding market rate, commodity rate, market news or market views, foreign exchange inquiry, dealing, obtaining current status of foreign currency rate, money market information accumulation etc

Note: Functions column refer to an identical and standard package of technology driven banking services and transactional capabilities provided by most of the commercial banks in Bangladesh especially the PCBs and FCBs.

Source: Author's survey in 2007 and Free On line Encyclopedia

**Table : A.1 : ROA and ROE of TAG and TNG : NCBs in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG	Y <sub>+1</sub> : 3 NCBs	0.00	0.00
	Y <sub>+2</sub> :3 NCBs	0.00	0.00
	Y <sub>+3</sub> :3 NCBs	0.00	0.00
	Y <sub>+4</sub> :3 NCBs	0.00	0.00
	Y <sub>+5</sub> :1 NCB	0.00	0.00
	Y <sub>+6</sub> :1 NCB	0.00	0.00
TNG: 1 NCB		0.00	0.00

Note : Percentage of Return on Asset (ROA) = (Net Income after Tax and Provision / Total Asset) \* 100.  
Similarly, Percentage of Return on Equity (ROE) = (Net Income after Tax and Provision / Total Capital and Reserve) \* 100. Since Net Income after Tax and Provision found zero for each of the NCBs in 2006 that results in zero ROA and ROE in Table A.1

Source : Author's calculations

**Table : B.1 : ROA and ROE of TAG and TNG : SBs in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG: Y <sub>+1</sub> : 1SB		1.87	22.25
TNG: 4 SBs		-0.0002	-0.001

Note : Since technology adopted group (TAG) consists of one specialized bank (SB), the result found for Y<sub>+1</sub> to Y<sub>+6</sub> groups of TAG remain unchanged and hence to avoid repetition results found for Y<sub>+2</sub> to Y<sub>+6</sub> are not shown .

Source : Author's calculations

**Table : C.1 : ROA and ROE of TAG and TNG : PCBs in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG	Y <sub>+1</sub> : 24 PCBs	1.17	16.69
	Y <sub>+2</sub> :21 PCBs,	1.24	17.80
	Y <sub>+3</sub> : 17 PCBs	1.31	18.62
	Y <sub>+4</sub> : 10 PCBs	1.31	19.41
	Y <sub>+5</sub> : 7 PCBs	1.35	19.88
	Y <sub>+6</sub> : 2 PCBs	1.54	21.65
TNG: 6 PCBs		0.35	5.05

Source : Author's calculations

**Table : D.1 : ROA and ROE of TAG and TNG : FCBs in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG	Y <sub>+1</sub> : 5 FCBs	2.19	24.74
	Y <sub>+2</sub> : 5 FCBs	2.19	24.74
	Y <sub>+3</sub> : 4 FCBs	2.20	25.75
	Y <sub>+4</sub> : 3 FCBs	2.18	26.63
	Y <sub>+5</sub> : 3 FCBs	2.18	26.63
	Y <sub>+6</sub> : 3 FCBs	2.18	26.63
TNG: N= 4 FCBs		1.84	6.94

Source : Author's calculations

**Table : E.1 : ROA and ROE of TAG and TNG : Selected 40 banks in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG	Y <sub>+1</sub> : N=30 (1 SB, 24 PCBs, 5 FCBs)	1.40	18.80
	Y <sub>+2</sub> : N=26 (21 PCBs, 5 FCBs)	1.46	19.74
	Y <sub>+3</sub> : N=21 (17 PCBs, 4 FCBs)	1.53	20.69
	Y <sub>+4</sub> : N=13 (10 PCBs, 3 FCBs)	1.58	22.02
	Y <sub>+5</sub> : N=10 (7 PCBs, 3 FCBs)	1.66	22.69
	Y <sub>+6</sub> : N=5 (2 PCBs, 3 FCBs)	1.98	25.25
TNG: N=10 (6 PCBs, 4 FCBs)		0.52	5.68

Source : Author's calculations

**Table : F.1 : ROA and ROE of TAG and TNG : All Schedule Banks in 2006**

(in percent)

Variable/ Ratios (Growth)		ROA	ROE
TAG	Y <sub>+1</sub> : N=33 (3 NCBs, 1 SB, 24 PCBs, 5 FCBs)	0.90	18.49
	Y <sub>+2</sub> : N=29 (3 NCBs, 21 PCBs, 5 FCBs)	0.90	19.37
	Y <sub>+3</sub> : N=24 (3 NCBs, 17 PCBs, 4 FCBs)	0.91	20.26
	Y <sub>+4</sub> : N=16 (3 NCBs, 10 PCBs, 3 FCBs)	0.83	21.41
	Y <sub>+5</sub> : N=11 (1 NCB, 7 PCBs, 3 FCBs)	1.27	20.43
	Y <sub>+6</sub> : N=6 (1 NCB, 2 PCBs, 3 FCBs)	1.25	21.18
TNG: N=15 (1 NCB, 4 SBs, 6 PCBs, 4 FCBs)		0.29	3.25

Source : Author's calculations