ATM USAGE AND PRODUCTIVITY IN THE BARBADIAN BANKING INDUSTRY

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**Abstract**

*This study examines the productivity impact of ATM deployment in the Barbadian banking industry over the period 1979 to 2001 using a Cobb-Douglas production function specification augmented with ATM implementation dummies. The panel regressions show that the introduction of ATMs increased bank productivity by between 3 to 17%.*

**Keywords:** Productivity, Banking, IT Deployment

## 1. Introduction

Information technology (IT) investment is an important element of new capital formation in the financial services sector. One development in the area of IT, the automatic teller machine (ATM), has become an integral part of the way Barbadians transact banking business. ATMs circumvent the need to join a bank queue by providing several services offered at the teller's station. Additionally, these machines offer services that would otherwise be unavailable, such as 24-hour access to funds at locations remote from bank branches. Several banks have also entered into mutual access arrangements via the CarIFS system, so that one institution's clients can access funds through another's ATM.

The main purpose of this paper is to investigate the effect of ATM deployment on bank productivity in Barbados over the period 1979 to 2001, using an unrestricted Cobb-Douglas production function. Few studies have investigated the effect of IT on productivity in the banking industry and have yielded conflicting results. For example, Frei, Harker and Hunter (1997) and Parsons, Gotlieb and Denny (1993), both utilising US banking data, report that IT investment has an insignificant effect on productivity, while Haynes and Thompson (2000), employing data on

UK building societies, find that the ATM innovation increases the productivity of adopters by between 7 and 9% relative to non-adopters.

Inherent in examining the impact of ATM technology on bank productivity is the difficulty of correctly defining the output variable. Haynes and Thompson (2000) utilse real earning assets while Frei, Harker and Hunter (1997) use total loans plus total deposits. However, the output of the banking firm should not be linked to a single indicator, but to a multiplicity of indicators that attempt to capture the many services offered by a commercial bank. In this regard, this paper departs from previous studies by obtaining estimates of bank output, which is consistent with international national accounting standards. The approach accounts for the services provided by commercial banks, which can be associated directly to fees charged, and for the intermediation services which are indirectly measured by comparing the interest paid and received to a reference or risk-free rate of interest. This research also adds to the literature on developing countries since most of the work on productivity has been undertaken on developed economies such as the US and UK. In addition, it provides policy makers, bankers and other interested persons with the first estimates of the impact of ATM deployment in Barbados.

This paper is divided into four sections. Following the introduction, Section 2 outlines the methodology and describes the data. Section 3 presents the empirical results while Section 4 concludes.

## 2. Methodology and Data

Following Haynes and Thompson (2000) and Frei, Harker and Hunter (1997) this study uses a Cobb-Douglas production function methodology to model banks' output determination. Before augmenting the ATM variables, the production frontier is assumed to be of the following form:

$$q_{it} = A_{it} L_{it}^{\beta_1} K1_{it}^{\beta_2} K2_{it}^{\beta_3} \tag{1}$$

where *i* is a firm index, *t* is time index, $q_{it}$ is an output indicator, $L$ is labour, $K1$ is fixed capital and $K2$ is a proxy for financial capital. Taking logarithms of Equation (1) and augmenting with the ATM binary variables, the estimation equation becomes:

$$\begin{aligned} \ln q_{it} = \alpha_i + \beta_1 \ln L_{it} + \beta_2 \ln K1_{it} + \beta_3 \ln K2_{it} + \beta_4 ATM_{it} + \\ \beta_5 ATML1_{it} + \ldots + \beta_9 ATML5_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

where $\alpha_i$ gives the firm-specific, fixed effects, *ATM* is a dummy variable which takes the value of 1 for the year ATM technologies are introduced by the $i^{th}$ bank and zero otherwise, while *ATML1-ATML5* are dummy variables which take the value of 1 for years one to five after ATM technologies are introduced and zero otherwise and $\varepsilon_{it}$ is an error term which is assumed to have normal properties. The signs of $\beta_1, \beta_2$ and $\beta_3$ are expected to be positive given that higher inputs should result in greater output. Similarly, the coefficients of the ATM dummies are expected to be positive, since the introduction of ATMs reduces the complement of staff and branches required by a given bank to undertake normal day-to-day operations. By extension, the lagged ATM dummies are included to test whether the introduction of ATM technologies affects bank productivity in periods other than the implementation year.

Pooled and fixed effects specifications of Equation (2) are estimated, along with various production function specifications such as the translog and the constant returns to scale models. The results from these latter specifications did not change the overall findings of the study and are therefore not presented. However, as Cable and Wilson (1989) shows, it is likely that the labour variable is endogenously determined in the specification given in Equation (2), therefore each model is also estimated by instrumental variables.

The output variable is derived using the methodology proposed by the System of National Accounts (SNA) 1993 (Commission of the European Communities, et. al., 1993). This approach disaggregates the output of financial intermediaries into two main components, financial intermediation services directly measured (FISDM) and financial intermediation services (the service of channelling funds from surplus to deficit economic agents) indirectly measured (FISIM). Eurostat (2001) recommends that real FISIM output be estimated as the sum of: (1) the difference between the interest actually charged on loans and the amount that would be paid if a risk-free rate is utilised, and (2) the interest that would have to be paid on deposits if the risk-free rate is used and the interest actually paid. The base year estimates of FISIM can then be extrapolated using real loans and deposits, respectively (the consumer price index is employed as the deflator in both instances). Financial intermediaries also provide other ancillary services for which there are explicit fees, such as currency exchange. These values can be deflated by a price index to give a real estimate of FISDM. The summation of real FISIM and FISDM therefore produces an output indicator, which is consistent with international national accounting methodologies. The definitions of the other explanatory variables are presented in Table 1.

The sample employed in this study consists of an unbalanced panel of the seven local commercial banks over the period 1979 to 2001. The summary statistics of the variables are given in Table 2 for five periods. The value of real output of commercial banks has generally trended upwards throughout most the period under consideration primarily due to a relatively robust rate of growth in real economic activity experienced during the period. Economic growth increases the demand for financial services and by extension the output of commercial banks. During the 1999-2001 period, average commercial bank output was estimated at \$65.8 million, which was more than double the level of output registered in the 1979-1983 period. As a result of the increased demand for financial services banks have significantly expanded their stock of fixed capital during the latter half of the 1990s. While in the 1979-1983 period the average bank held \$8.1 million in real fixed assets, by 1994-1998 the stock had risen to \$17.0 million and to \$27.5 million over 1999-2001. Similar expansions in other earning assets were also observed reflecting an increase in the proportion of commercial bank assets held in investments.

## 3. Results

Table 3 reports the unrestricted Cobb-Douglas estimation results using the pooled, fixed effects and instrumental variables estimators. The three models are presented for comparison purposes; however, a Wald test showed that the fixed effects specification is superior to the pooled model. In addition, the instrumental variables estimator model allows the labour variable to be endogenously determined. Therefore, the remainder of this section will focus, for the most part, on the estimation results from the production function model estimated by the instrumental variables technique. The model accounts for at least 85% of the variation in output in the basic production function specification. In addition, the chi-square statistic shows that the regression model provides an adequate representation of the data generating process of commercial bank output. In the basic production function model estimated by fixed effects both the labour and fixed capital variables are insignificant determinants of output. The insignificance of the K1 variable seems to be associated with the endogeneity of the labour indicator, since when instrumental variables is employed, both labour and capital are positively and significantly related to output.

Turning now to the variables of interest, the ATM dummies, chi-square tests statistics, which assess the joint significance of the ATM dummies, yields values of 62.4 for the pooled model, 5172.2 for the fixed effects specification and 59.3 for the instrumental variables model, which are all significant at the 1% level of testing. These results indicate that the coefficients of the ATM variables cannot be restricted to zero. The coefficient estimates show that in the first three years of using ATM technologies bank productivity usually declines. This could be associated with cost related to staff training and difficulties in encouraging customers to utilise the new technology. However, after this initial period, productivity increases are positive. The coefficient estimates range from 0.03 and 0.18 in these periods and are equivalent to a productivity gain of approximately three to eighteen percent.[1] This estimate is consistent with the productivity gains of between 7 and 9% reported by Haynes and Thompson (2000) for the introduction of ATM technologies among UK building societies.

## 4. Conclusions

This study has used an augmented production function approach to explore the productivity effects of ATM introduction on Barbadian commercial banks over the period 1979 to 2001. The results show that ATM introduction initially lowers bank productivity due to implementation costs related to staff training, customer awareness programmes and the like. However, after the technology has been fully implemented and is being effectively utilised, the productivity gains range from 3% to 17% in any given year.


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[1] A similar result is obtained if the dependant variable is specified analogous to those used by Frei, Harker and Hunter (1997) and Haynes and Thompson (2000).

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**Table 1: Definition of Variables**

| Variables | Definition |
|---|---|
| Q | Total value of financial services provided by the bank expressed in constant 1995 prices |
| L | Total number of employees |
| K1 | Book value of premises and fixed assets expressed in constant 1995 prices |
| K2 | Other earning assets (such as investments, etc.) expressed in constant 1995 prices |
| ATM | Dummy variable which takes the value 1 for the year ATM technologies are introduced and zero otherwise |
| ATML1-ATM5 | Dummy variable which takes the value 1 for years one to five after ATM technologies are introduced and zero otherwise |

**Table 2: Summary Statistics**

| Variables | Years | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1979-1983 | | 1984-1988 | | 1989-1993 | | 1994-1998 | | 1999-2001 | |
| | Mean | S.E. | Mean | S.E. | Mean | S.E | Mean | S.E. | Mean | S.E. |
| Q (BDS $Mil) | 29.7 | 16.0 | 33.3 | 19.3 | 36.6 | 19.9 | 48.2 | 25.0 | 65.8 | 36.5 |
| L (Persons) | 221.3 | 161.6 | 202.0 | 158.8 | 257.2 | 175.3 | 276.3 | 153.1 | 286.3 | 139.4 |
| K1 (BDS $Mil) | 8.1 | 9.4 | 8.4 | 7.6 | 11.4 | 9.8 | 17.0 | 11.1 | 27.5 | 15.3 |
| K2 (BDS $Mil) | 45.9 | 26.3 | 59.4 | 30.9 | 73.0 | 37.8 | 108.8 | 70.8 | 118.9 | 68.9 |

**Table 3: Estimated Production Function**

| Variable | Pooled Model | Fixed Effects | IV | Pooled Model | Fixed Effects | IV |
|---|---|---|---|---|---|---|
| L | 0.401 | 0.328 | 0.313 | 0.400 | 0.446 | 0.278 |
| | (0.172)* | (0.294) | (0.112)** | (0.194)* | (0.288) | (0.120)* |
| K1 | 0.108 | 0.163 | 0.147 | 0.105 | 0.085 | 0.164 |
| | (0.081) | (0.130) | (0.051)** | (0.093) | (0.133) | (0.052)** |
| K2 | 0.416 | 0.255 | 0.465 | 0.430 | 0.171 | 0.509 |
| | (0.092)** | (0.054)** | (0.077)** | (0.108)** | (0.040)** | (0.079)** |
| Constant | 2.718 | - | 2.281 | 2.633 | - | 1.892 |
| | (0.605)** | | (0.462)** | (0.895)** | | (0.629)** |
| ATM | - | - | - | -0.242 | -0.122 | -0.269 |
| | | | | (0.068)** | (0.073) | (0.102)** |
| ATML1 | - | - | - | -0.194 | -0.045 | -0.235 |
| | | | | (0.083)* | (0.079) | (0.062)** |
| ATML2 | - | - | - | -0.058 | -0.056 | -0.049 |
| | | | | (0.088) | (0.070) | (0.100) |
| ATML3 | - | - | - | 0.064 | 0.097 | 0.030 |
| | | | | (0.071) | (0.084) | (0.055) |
| ATML4 | - | - | - | 0.063 | 0.080 | 0.059 |
| | | | | (0.055) | (0.049) | (0.056) |
| ATML5 | - | - | - | 0.179 | 0.191 | 0.167 |
| | | | | (0.042)** | (0.033)** | (0.060)** |
| | | | | | | |
| R-Squared | 0.866 | 0.906 | 0.853 | 0.879 | 0.920 | 0.866 |
| $\sigma$ | 0.307 | 0.263 | 0.322 | 0.298 | 0.249 | 0.312 |
| $\chi^2$ | 697.5** | 113.2** | 463.5** | 82.5** | 361.6** | 26.7** |
| Obs | 157 | 157 | 157 | 157 | 157 | 157 |

Notes: White robust standard errors are reported in parentheses below the coefficients.
**, * denotes significance at the 1 and 5 percent level, respectively.
Instruments used are real national income growth, total assets, a trend and the ATM dummies.