Determinants of automated teller machine deployment in commercial banks of Ethiopia

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ABSTRACT

The increasing development of transaction technology investment in the financial sector of the national economy especially Automated Teller Machine (ATM) in Ethiopia banking industry is below customers demand. The availability and deployment of ATM in Ethiopia is low-level compared to the fast growing urban population. Thence, the prime objective of this paper is to evaluate the determinants of ATM deployment in commercial banks of Ethiopia. In order to achieve the objective, panel data was gathered from thirteen Ethiopian commercial banks for the sampled time period beginning from 2012 to 2016. This study used descriptive statistics and panel data econometric regression analysis to analyze the data collected. The random effect model was employed as a reasonable fit model for this study and interpretations of estimates were made based on this model. The result of the descriptive analysis indicated that the trend of ATM deployment in commercial banks of Ethiopia was rising over the sample time period. The results investigated from random effect model indicated that that bank size, bank profitability and deposit ratio were statistically significant and had positive impact on ATM deployment. Meanwhile, cost efficiency and number of branches had statistical insignificance relationship with ATM deployment in Ethiopian commercial banks. Based on these findings, it is recommended that the commercial banks of Ethiopia or any concerned body need to envisage the bank size, bank profitability and deposit ratio in introducing and expansion of ATM and any other electronic form of payments.

1. Introduction

Modern financial technology has become a very critical aspect of recent banking services delivery in the world at large and African countries in particular. ATM is one of the foremost indicators for this technical know-how and is adopting by commercial and non-commercial banks with in the globe (Otukoya, 2014). It is a device that provides access to customer in financial transaction and many other activities or duties without the need of human or teller on banking and financial institutions. In the modern times, customers are identified by the machine through inserting plastic ATM card containing unique card number and some security information such as personal identification number and date of expiration (Solomon, 2010). ATM provides host of benefits for both banks and their depositors. With this machine, customer can withdraw, transfer, exchange the currency at convince places, and time than through face to face interaction only at banking working hours (Olatokun, 2009) (see Tables 1, 2 and 3).

The financial sectors of the economy in many developing countries have accelerated their services by the use of ATM. The aim has been to schedule workers’ duties in a simplest way, decrease the building upon queues and enhance workers’ productivity. Reduction of customers’ service delivery time, improvement of services quality, bringing and expanding services closer to customers and cost-effective operations are considered as other reasons for the deployment of ATM. In these veins, the overall aim is to reap the benefit of attaining the highest possible level of profit (Steve, 2002; Huang, 2012; Husse in, 2017).

In Ethiopia, the development of ATM banking services is through gradual and the time where the deployment of ATM started in the late 2001. Commercial Bank of Ethiopia, the largest state owned bank has introduced and expanded ATMs to deliver different services to customers inter alia, cash withdrawal, foreign exchange to domestic users, and payment of bill (Gardachewetal, 2015). Moreover, ATM has become the most competitive instrument to commercial banks of Ethiopia (Wale, 2011). Thus, adequate ATM deployment policies are highly required to
increase the number of ATM and quality of the services offered. Comparing to other African countries, the deployment of ATM is still low-level in Ethiopia. For instance, ATM deployment in Nigeria is 150,000 ATMs per 100,000 persons (Amefrele, 2012).

In the year 2016, the number of commercial banks of Ethiopia has reached 18, out of which 16 are private, and the remaining 2 are state owned. The total branches in the country have reached to 3,023 in quantity which is not capable of residents demand for financial services.

Besides, the number of population was 101,853,268 of which 81,650,453 were living in rural areas where financial institutions have not yet reached to majority of those people whereas, the remaining 20,202,815 are urban dwellers who got benefits from this service. But, the proportion of ATM to urban population was very small (NBE, 2015). In Ethiopia, ATM is suited mostly near or inside the premises of commercial banks revealing the deployment of ATM is low level compared to the fast growing urban population. As a result, the deployment of ATMs in shopping center, grocery stores, airports, restaurants, petrol stations, and any other places where large number of people can be out-reached are rare or scanty available.

Table 1. Results of descriptive statistics for the entire sampled period of selected banks.

| Variables                        | Obs. | Mean   | Std. Dev. | Min.  | Max.   |
|----------------------------------|------|--------|-----------|-------|--------|
| ln of number of ATM deployment   | 65   | 3.809  | 1.245     | 0.692 | 7.314  |
| ln of bank size                  | 65   | 9.233  | 1.214     | 7.12  | 13.222 |
| Bank profitability               | 65   | 4.811  | 1.37      | 2.1   | 8.5    |
| Deposit ratio                    | 65   | 0.764  | 0.048     | 0.629 | 0.9    |
| Cost efficiency                  | 65   | 0.045  | 0.015     | 0.016 | 0.096  |
| Number of branches               | 65   | 151.431| 214.337   | 1     | 1137   |

*Source: Own Computations via Stata 12 Using Data Collected from Head Office of each Bank and NBE, 2018*

Table 2. Regression results of the three models.

| Variables | Models | Pooled OLS | Fixed effect | Random effect |
|-----------|--------|------------|--------------|---------------|
|           |        | Coefficients (Robust S.e, P-Value) | Coefficients (Robust S.e, P-Value) | Coefficients (Robust S.e, P-Value) |
| lnBsize   | .947   | (.138, 0.000*) | 1.051 (.257, 0.000*) | .894 (.166, 0.000*) |
| Prof      | .139   | (.059, 0.022**) | .067 (.0967, 0.712) | .117 (.069, 0.092***) |
| Dsr       | 2.668  | (1.566, 0.094***) | 2.135 (1.813, 0.245) | 2.932 (1.543,0.057***) |
| Ge        | 7.235  | (5.683, 0.208) | 5.886 (6.711, 0.385) | 8.025 (5.582, 0.151) |
| Br        | -.00069| (.0006, 0.316) | .0009 (.011, 0.436) | -.0009934 (.0008, 0.913) |
| Constant  | -7.876 | (1.535, 0.000) | -8.105 (2.152, 0.000) | -7.607 (1.701, 0.000) |
| Obs.      | 65     | 65        | 65          | 65           |
| R²        | .8293  | .7935     | 8.256       |               |
| F(5,59)   | F(5,47)| .57       | 22.61       |               |
| Prob > F  | .0000  | .0000     | .0000       |               |
| [95 % Conf. Interval]            | .5671639 | 1.221049 |               |               |

*Source: Own Computations via Stata 12 Using Data Collected from Head Office of each Bank and NBE.*

Table 3. Regression results of random effect model.

| LnNATM   | Coefficients | Robust Std. Err. | z    | P > z  | [95 % Conf. Interval] |
|----------|--------------|------------------|------|--------|-----------------------|
| lnBsize  | .894         | .166             | 5.36 | 0.000  | .5671639              |
| Prof     | .117         | .069             | 1.69 | 0.092  | .018939               |
| Dsr      | 2.931        | 1.544            | 1.90 | 0.057  | -.9300725             |
| Ge       | 8.0245       | 5.583            | 1.44 | 0.151  | -2.91792618           |
| Br       | -.0000934    | .00885           | -0.11| 0.913  | -.0017699             |
| cons     | -7.607       | 1.701            | -4.47| 0.000  | -10.942484            |
| sigma_u | .43516463Wald chi2 (5) = 174.48 |               |     |        |                      |
| sigma_e | .4230511Prob > ch2 = 0.0000 |               |     |        |                      |
| rho     | .51411198 (fraction of variance due to u_i)R squared = 0.8256 |               |     |        |                      |
| Number of observation = 65       |               |                 |     |        |                      |

*Source: Own Computations via Stata 12 Using Data Collected from Head Office of each Bank and NBE.*

Note: *significant at 1 %, **significant at 5 %, and ***significant at 10 %.

In Ethiopia, host of previous researchers’ (e.g. Gemechu, Adewoye, 2013) found that salary level, firm size, competitive pressure value of ATM transactions, and bank profitability might significantly affect ATM deployment in commercial banks of Nigeria. According to (Liu, 2009), the most important determining factors of ATM deployment in Taiwan banking were operating scale, deposit service and cost of operating (Hannan, 1984). found that the direction of influence for wage rate and firm size on the decision to adopt ATM were positive. Stating differently, with higher wage rate, banks tend to install more ATM to substitute expensive labor and according to economic scale theory, larger and cost-effective banks tend to introduce more ATM as compared to small banks do. In Ethiopia, host of previous researchers’ (e.g. Gemechu, Ademe et al., 2021).
The advantage of qualitative research methods is that it provides a more realistic sense of the world, which cannot be experienced with numerical data and statistical analysis used in quantitative research. They are a flexible way to perform data collection, post-analysis and interpretation of the collected information. In addition, it provides a holistic view of the phenomenon under investigation, and researchers can interact with the research subjects in their own language and on their own terms (ibid.). Despite the above advantages, qualitative research design has its own limitations. First, it takes a long time to collect, analyze, and interpret data, which means that researchers must spend a lot of time in the research environment to comprehensively and comprehensively examine interactions, reactions, and activities. Second, the research design lacks standard rules, emphasizes giving meaning and explanation to events and things, and reduces objectivity. Third, in qualitative research, according to the personal characteristics of the researcher (subjectivity) and the inability to investigate the causal relationship between different research phenomena, the research draws different conclusions based on the same information. Fourth, the results of qualitative research cannot be statistically generalized to a wider range of stakeholder groups because they are based on a small number of unrepresentative survey cases.

3.1.2. Mixed research approach
A hybrid approach is defined as a researcher’s tendency to base knowledge claims on a pragmatic basis (eg, results-oriented, problem-focused, and diversified). It uses a research strategy that involves collecting data simultaneously or sequentially to better understand the research question. Data collection also includes the collection of digital and textual information so that the final database can represent both quantitative and qualitative information. Therefore, when methods are combined, the strengths of each method complement the strengths of the other methods, resulting in a more powerful research design, resulting in more effective and reliable discoveries. In fact, the shortcomings of the individual methods are reduced (Creswell, 2009).

3.1.3. Quantitative research approach
The basis of quantitative research is post positivist knowledge claims, which primarily reflect the scientific methods of the natural sciences. This paradigm uses a deductive approach to the research process. Researchers collect real-world data and then perform statistical analyses of the data to support or reject hypotheses (Babbie, 1995). Researchers who adopt more deductive methods use theory to guide research design and interpretation of results. Accordingly, the overall goal of quantitative research is to test or verify theories, not to develop them. Therefore, the theory provides a conceptual framework for all research and an organizational model for the entire data collection process (Churchill, 2005). By considering quantitative techniques as an attempt, incorporating hypotheses in the research design and responding to hypotheses by measuring their strengths and weaknesses, the data collected can be measured numerically. Quantitative researchers focus on procedures, methods, and statistics. Therefore, it relies on statistical techniques assisted by computational algorithms and software packages to analyze the problem under study. Quantitative research is research in which researchers primarily use positivism claims to develop knowledge, and their research strategies are related to research methods and experiments.

The experimental research aims to determine if a particular treatment will affect the result. The method of assessing this impact is to provide a specific treatment to one group, then hide it from the other group, and then determine the scores for the two groups in the results. Thus, pure experiments allow researchers to manipulate independent variables to see the effects on dependent variables by assigning subjects randomly to treatment conditions, whereas quasi-experiments use non-randomized designs and are single-subject designs, while that survey studies provide descriptions of attitudes or opinions about research trends across research population samples. It includes cross-sectional research and
longitudinal to collect data through questionnaires, structured interviews, and document reviews, with the purpose of generalizing from the sample to the general (Creswell, 2009).

The advantage of well-planned and implemented quantitative research is that it can generalize a wider population based on the findings of the sample. In order to improve the universality of research results, quantitative research methods at least theoretically follow standardized procedures for sample selection, instrument design, implementation, and analysis. In turn, this standardization will increase the duplication of procedures and the reliability of survey results, and can also reduce the influence of interviewer's biases (ibid.).

Despite the above advantages, the quantitative research design still has many limitations. First, it degrades the human personality and the ability to think. Second, it did not provide the researchers with information about the context in which the phenomenon under study occurred. Third, due to the closed questions and structured format, its results are limited to those described in the original research plan. Finally, quantitative research appears to lack design flexibility, which can arise when additional information revealed through data collection must be knowledgeable (ibid.).

Generally, according to (Mckerchar, 2008), in addition to the basic philosophy of each research method, the choice between the three research methods is mainly guided by the research question. In other words, if the research question is based on the framework, through literature review and predictive information collected before the research or allow it to emerge from project participants or both. According to the research goals and assumptions put forward at the beginning of this chapter and the basic philosophy of each research method. For this study, the researchers adopted quantitative approach as the objectives of the study was to quantify data by generalizing results from sample to population and the data were presented in the form of numbers and statistics. In addition, both the dependent and independent variables are continuous (Bhattacherjee, 2012).

3.2. Research design

The choice of research design depends on what the researcher wants to achieve (Alemayhu, 2009).

3.2.1. Exploratory research

It is usually carried out in a new field of investigation. The goal of the investigation is to determine the severity or scope of a particular phenomenon, problem or behavior, generate some preliminary ideas about the phenomenon, and test the feasibility of conducting an investigation. This phenomenon has been studied more extensively. It involves multiple research methods to achieve its goals: in-depth informal/formal interviews, focus group discussions, case studies, etc (Catherine, 2007).

3.2.2. Descriptive research

It is making careful observations and detailed documentation of a phenomenon of interest, the objective is to describe some aspect of a phenomenon, i.e., the status of a given phenomenon. It can help understand a topic and lead to causal analysis and involves a variety of research methods to achieve its objectives: Surveys, correlation studies, observation studies and case studies (Anol, 2012).

3.2.3. Explanatory research

Seeks explanations of observed phenomena, problems or behaviors and seeks answers to why and how types of questions. Attempt to connect the dots in research, by identifying causal factors and outcomes of the target phenomenon. It involves: Explaining things not just reporting. Describing and develop a theory's explanation, determining which of several explanations is best, determining the accuracy of the theory, test a theory's predictions. It also examines the causal relationship between the outcome variable and the regressor variable (Kothari, 2004). Therefore, the study uses explanatory research designs and panel data sets to solve broader and more complex problems to examine the relationship between the dependent variable and the dependent variable across time. Panel data structured the model in an appropriate way it can improve the impact of certain forms of omitted variables bias in regression results (Brooks, 2014). It is a set of data that observe the behavior of entities over time, because panel data allows researchers to control variables that cannot be observed except for pure time series or pure cross-sectional data (Baltagi, 2008).

3.3. Target population and sampling

The target population for this study was both state owned commercial bank of Ethiopia and privately owned Banks. According to the national bank of Ethiopia (2015/16) report, there are 18 banks in Ethiopia. Using purposive judgmental sampling, thirteen banks were chosen: Bank of Abyssinia, Commercial Bank of Ethiopia, Wegagen Bank, Awash International Bank, Dashen Bank, United Bank, Nib International Bank, Lion International Bank, Zemen Bank, Berhan International bank, Abay Bank, Oromia International Bank and Cooperative Bank of Oromia. The time period for the study is 2012–2016. This period is selected to get well organized and balanced data as ATM is a recent phenomenon in the study area.

3.4. Nature and tools of data collection

This study collected longitudinal or panel data from banks at different time periods. Stating differently, to achieve the above-referenced research objectives, secondary source of data was garnered. It is data and information which already exists in some forms but which was not primarily collected at initially, for the purpose of the study at hand and it is data that is being reused (Bougie, 2010). The data collection tools for this study include public or unpublished forms of official records or document analysis of the annual audited financial statements of the Ethiopian Commercial Bank.

3.5. Dependent and determining variables, and measurements

The variable employed in this study was ATM deployment which is measured in terms of number of ATM deployed by banks. The motive for deploying ATMs are based on cost saving measured by natural logarithm of the number of ATM. Whereas, bank size (Bsize), bank profitability (Prof), deposit ratio (Dsr), cost efficiency (Ce), and number of branch (Br) were considered as independent variables, that explain the adoption of ATM. All of the above variables are adopted from previous studies, for instance from Chin et al., (2009), Hannan (1984) and others based on the degree of their effect on ATM deployment. The actual bank size has been found to have a positive impact in determining ATM deployment.

Hwang et al. (2004) found that the results are consistent with the economic scale theory; compared with small banks, large banks tend to invest more in ATMs. They also examined the important determinants of the adoption of data warehouse technology in Taiwan’s banking industry, and proposed that the size of the bank influences the adoption of data warehouse technology. They believe that the scale of business is based on total assets, the number of branches, and the growth of branches. They are positive and meaningful.

Return on equity (Measures the return to share holder capital) or Return on Assets (Measures income earned on each asset unit) can be the measures of profitability. However, for (Adewoye, 2013), ROA is the measure of profitability for banks. Hence, in this paper, ROA (the ratio of net income after tax to its total asset) was used as the key measure of profitability. Profitable banks would invest more in asset acquisition including investment on electronic payments. Prior studies found inconclusive relationship between profitability of banks and information technology investments; this is true in the short run. This is because the investment cost of information and communication technology is high (Huang, 2012). However, most recent studies found that there is a...
positive relationship between profitability of banks and investment in information technology such as ATM. (Milne, 2006) described that the modernization of digital services in the financial sector laid the foundation for astonishing improvements in global banking procedures.

According to (Yen, 2011), the bank with higher customer demand for deposit service (The ratio of total deposit to total asset) tend to invest more on ATM because the banks invest on modern technology particularly ATM to increase customer satisfaction and thereby to attract new deposits. Further, banks with higher operating expense oblige to invest more on ATM to improve cost-performance. Thus, the relationship between operating expense and ATMs investment are positive. Cost efficiency is the ratio of operating expense to total deposit (Ou, 2009) for this study. Finally, when the bank expands the number of branches for deposit mobilization, it may also expand the technology like ATM to convince and attract customers in line with the branch (Ibid). Consideration of multiple independent variables in the model will never indicate that there are no missing variables in the model (Brooks, 2014). Therefore, researchers have included error terms in the econometric model specifications to reduce the impact of missing variables in the model.

3.6. Model specification

The data obtained was specified using the panel data regression model to investigate the determining factors of ATM investment. The regression model for panel data is available in most recent literatures (William, 2008; Wooldridge, 2002) has the following general form.

\[
Y_{it} = \beta_0 + \beta X_{it} + \epsilon_{it}
\]

where: \( Y_{it} \) is the outcome variable for individual bank ‘i’ in time period ‘t’, \( \beta_0 \) is the intercept term, \( \beta \) is the vector of coefficients, \( X_{it} \) is the vector of exogenous variables for entity i in time period ‘t’ and \( \epsilon_{it} \) is the disturbance term. As a result, the econometrics model is specified as follows for this research.

\[
\text{NATM}_{ia} = \beta_0 + \beta_1 (\text{Bsize})_{ia} + \beta_2 (\text{Prof})_{ia} + \beta_3 (\text{Dsr})_{ia} + \beta_4 (\text{Ce})_{ia} + \beta_5 (\text{Br})_{ia} + \epsilon_{ia}
\]

where

- \( \beta_0 \) is an intercept.
- \( \beta_1, \beta_2, \beta_3, \beta_4 \) and \( \beta_5 \) represent estimated coefficients of the independent variables for banks at time ‘t’.
- \( \text{Bsize}, \text{Prof}, \text{Dsr}, \text{Ce}, \text{Ce} \) and \( \text{Br} \) represent bank size, bank profitability, deposit ratio, cost efficiency and number of branches respectively.
- \( \epsilon_{ia} \) denotes the disturbance term. It is assumed that this term has followed the classical linear regression assumptions.

The estimators in econometrics model are Pooled OLS, Random Effect and Fixed Effect.

3.7. Comparisons of pooled OLS vs panel model estimators

In this research, Breusch-Pagan Lagrange Multiplier (LM) was employed to know whether the pooled OLS or random effect model is preferred. The same observations are used over time and unobserved heterogeneity can be controlled in panel data whereas pooled OLS data can’t control unobserved heterogeneity and has the problem of omitted variables. Pooled OLS is very essential procedure that applies when it has a panel data, pool the data and estimate OLS regression. So, if there is a constant term, OLS is consistent and efficient estimate of \( \beta_0 \) and the slope vector \( \beta \) (Green, 2012). Meanwhile, the panel frame work explains that there are K regressors in Xit with no constant term.

The null hypothesis in the LM test is variance across entities is zero or there is insignificant difference across units or no panel effect that means pooled OLS is appropriate using command xtest0 (William, 2008). We have also used F-test to identify whether pooled OLS or fixed effect is a better fit model for this study. The null hypothesis under this test is that pooled OLS is appropriate for the study while rejecting the null hypothesis implies fixed effect is an appropriate model (Green, 2012).

3.8. Comparisons of fixed vs. random effect model

Fixed effect (within estimator) design allows for the unit specific effect (unobserved heterogeneity or omitted) to be correlated with the regressor whereas, the random effect (covariance model) assumes that the unit specific effect is uncorrelated with the regressor. The researchers have considered Hausman test (Using command Hausman fixed random) to decide whether random effect or fixed effect model fits the data well. The null hypothesis states that the better model is random effect: there are no correlation between regressor and unobserved effects (James, 2007).

3.9. Specification test

In order to determine whether the model used in the study is suitable and in line with the assumptions of the classical linear regression model, various diagnostic criteria tests, such as linearity, normality, heteroskedasticity, serial autocorrelation, and multicollinearity tests, performed. To clarify, in order to check the degree of possible multicollinearity between variables, an inflation factor of variance is used. Moreover, serial correlation was tested by Wooldridge autocorrelation. Whereas, the remaining tests, linearity and normality can be tested by Ramsey reset test and Shapiro W/Normality P–P plot respectively (Wooldridge, 2002).

3.10. Method of data analysis

The collected data should be analyzed according to the purpose of the research plan (Kothari, 2004). This research is based on panel data collected from 13 commercial banks during 2012 and 2016, through descriptive and econometric analysis. After collecting data from second-hand sources, it is coded, verified, and entered into a simple Excel program for final analysis. Then use the STATA version 12 statistical software package to analyze the collected data.

4. Results and discussions

4.1. Descriptive statistics

From the table provided below, the mean of ATM deployment for the selected banks throughout the study period reflects 3.809 and the standard deviation was 1.245. The minimum and maximum number of automated teller machine was 0.692 and 7.314 respectively. The mean of bank size measured by total asset is 9.233 and the minimum is 7.12 and the maximum is 13.272 with standard deviation of 1.214. The mean return on asset is 2.1 and the maximum return on asset is 8.5 with standard deviation of 1.37. For the variable deposit ratio a deviation from the mean of 0.764 is about 0.486 with range between 0.629 and 0.9. The efficiency of costs of banks reflected by total non-interest expense to total deposit showed that the mean was 0.045 and the standard deviation was 0.015, and the lowest and highest value of deposit ratio were found to be 0.016 and 0.096 respectively. The mean with regard to branches measured by the number of branches of each selected banks is 151.431 with deviation of 214.337 ranging between 1 branch to 1137 branches.

4.1.1. Analysis for automated teller machine Trend’s from 2012-2016

This section revealed the patterns or trends for number of ATM in Ethiopian commercial banks of Ethiopia during the time period in consideration. As shown in Figure 1 below, the trends of ATM deployment for 2012 to 2016 are slightly or inconsiderably rising for
commercial banks of Ethiopia. A slight increase in the number ATM might be due to higher bank size, profitability and deposit ratio and other factors.

4.1.2. Model specification test

The panel model first compares the three models: the combined regression model, the fixed effects model, and the random effects model, and then estimates the parameters. Therefore, the choice between mixed OLS, fixed-effects, and random-effects models is very important because it greatly influences the conclusions about individual coefficients (Gujarati, 2004). The F-test is validated for comparing fixed effect over pooled regression. The null under F-test is pooled regression is appropriate meaning there is no significant difference across various banks while the alternative hypothesis is fixed effect appropriate. As the test statistics in the F test is statistically significant ($F (12, 47) = 3.98; \text{Prob} > F = 0.000)$, the researchers have rejected the null hypothesis of pooled regression is appropriate and the fixed effect is appropriate.

The Breusch and Pagan Lagrange Multiplier test was undertake to make a decision between the pooled regression model and the random effect model. The null hypothesis of this test states that the variance of the random error is zero or no panel effect. The result of this test was statistically significant with p-value, ($\chi^2 = 15.14$), $\text{Prob} > \chi^2 = 0.0000$ and suggested that random effect is a better model, the null hypothesis was rejected.

In addition, a Hausman test is performed to choose between a fixed effects model and a random effects model, because fixed effects and random effects are selected on the combined regression model. The result of Hausman test portrayed the acceptance of the null hypothesis ($\text{Prob} > z = 0.7438$), indicating the random effect model is a reasonable fit model than the fixed effect.

Therefore, the regression results from the random effects model study are used for interpretation of variables coefficients and statistical inference.

4.1.3. Diagnostic tests of classical linear regression model assumptions

In order perform hypothesis tests about the model parameters, normality assumption is needed. This assumption stated that normality of the residual shows the estimators are unbiased, minimum variance, and consistent (Brooks, 2014). To know the normal distribution of the disturbance term, Shapiro Wilk test was deployed. Result of this test ($\text{Prob} > z = 0.00390$) was statistically significant revealing as the null hypothesis of error term was normally distributed.

The severity of the problem of correlations across exogenous variables is detected through variance inflation factors (VIF). As a rule of thumb variables are considered as highly collinear if the variance inflation factor greater than ten (Gujarati, 2004). In this study, the result showed that mean VIF was 3.08 which is lower than 10 and suggested that the abbesses of severe multicolinearity problem in the estimated model. Further, the Ramsey reset test was performed to test the appropriate model is linear in the parameters (Brooks, 2014). As a result, the p-value is statistically insignificant ($\text{Prob} > F = 0.8137$) supporting the null hypothesis of the functional form is linear.

Modified Wald test was employed to diagnose Heteroskedasticity (Wooldridge, 2002). The null hypothesis of this test stated that the variance of the error is homoscedasticity or constant and the result was statistically significant indicating non-existence of constant variance which would results spurious estimates. However, for the purpose of coefficient estimates interpretation, problem of heteroskedasticity are controlled using clustered robust standard error. Moreover, Wooldridge test was taken to diagnose the problem of serial correlation with the null hypothesis of there is no first order autocorrelation. Wooldridge test indicated statistically insignificant ($\text{Prob} > F = 0.2635$) result, supporting the null hypothesis of there is no first order autocorrelation.

4.2. Econometrics results and discussions

In the first step, the pooled OLS were estimated, from which the results were used as starting values for fixed and random effect models. As shown from the table below, among the five explanatory variables, only the coefficient of bank size (ln Bize) is significant at 1 % for the three models. The variable profit ($\text{Prof}$) is statistically significant at 5 % and 10 % for the pooled and random effect model respectively, and deposit ratio ($\text{Drs}$) is statistically significant at 10 % for both pooled and random effect models. Meanwhile, cost efficiency ($\text{Ce}$) and number of branches (Br) were found to be insignificant on the deployment of ATM (NATM) in commercial banks of Ethiopia for the three models employed. Despite,
Among the also important that the value of P is zero, indicating that the regressor in model, the R squared is 82.56 %, while the remaining changes in the model is best explained by the independent variables contained in the pooled model. Whereas, 79.35 and 82.56 % of the change in the interest variation in ln of number of ATM is described by the variables in the pooled model. The implication is that when bank size increases by 1 %, then ATM deployment would rises by 0.894 %, ceteris paribus. This result con

The econometric results showed that the dependent variable of the model is best explained by the independent variables contained in the model, the R squared is 82.56 %, while the remaining changes in the deployment of ATMs are not explained by the exogenous variables. It is also important that the value of P is zero, indicating that the regressor in the model can explain all the changes in the dependent variable. Among the five variables considered in the random effect model, ln of bank size, banks profitability and deposit ratio were found to be significant determinants of ATM deployment. The ln of bank size is statistically significant at 1 % with z value of 5.36 and had positive impact on the deployment of ATM. The implication is that when bank size increases by 1 %, then ATM deployment would rises by 0.894 %, ceteris paribus. This result confirms the researchers' a priori expectation of a significant relationship between bank size and ATM deployment.

Hence, the researchers have been accepted the alternative hypothesis of Bank size has a significant impact on ATM deployment in Ethiopian commercial banks. This result is also in line with the theory of economic scale; small banks tend to introduce fewer ATMs as compared to large banks (Hannan, 1984).

The second significant variable in this model was bank profitability. This variable is statistically significant at 10 % with z value of 1.69 and has positive effect on ATM deployment in commercial banks of Ethiopia. The implication is that when bank profitability increases by one birr per year, ATM deployment rises by 0.117 % suggesting profitable banks would invest more in asset acquisition including investment in information and communication technology. Precursor researches investigated inconclusive relationship between the profitability of banks and IT investments. But, recent studies including this study found significant relationship between bank profitability and ATM deployment (Milne, 2006). The output of this study also showed that the ratio of total deposit to total asset is statistically significant at 10 % with z value of 1.90 and positively related to ATM deployment. The implication is that when banks deposit ratio increase by one birr per year, ATM deployment rises by 2.931 % indicating that the greater the ratio of deposit, the better the deployment of ATM in commercial banks of Ethiopia. This suggested that banks with higher customer demand for deposit service tend to invest more on ATM because banks investment on modern technology particularly ATM can increase customer satisfaction and thereby to attract deposits (Yen, 2011).

On the other hand, the p-values of cost efficiency and number of branches were statistically insignificant. The variations in ATM deployment were basically different across banks based on their cost efficiency and number of branches. This result is inconsistent with the finding investigated by (Ou, 2009), found both cost efficiency and number of branches have significant impact on ATM deployment.

5. Conclusions and policy implications

The main objective of this study is to investigate the determinants of ATM deployment of Ethiopian commercial banks based on the analysis of balanced panel data from 2012 to 2016. This study has applied and passed various model specification tests, and random effect model was selected among fixed effect and pooled OLS regression analysis. Hence, the collected data was analyzed using random effect regression analysis and interpretations of estimates were made based on the results investigated from this model. The result of the descriptive analysis indicated a slight increase in ATM deployment in commercial banks of Ethiopia over the study time period.

Empirical results of random effect model revealed that bank size, bank profitability and deposit ratio were statistically significant to explain the number of automated teller machine in commercial banks of Ethiopia. The directions of influence for these variables were positive with researchers’ priori intuition. Specifically, the finding indicated that bank size had positive and statistically significant impact on ATM deployment. This result is consistent with the economic scale theory. This means that small banks tend to introduce fewer ATMs than large ones. Similarly, the study also found that bank profitability has a positive and statistically significant impact on Ethiopian commercial bank ATM deployment, meaning that banks with higher ROA have better ATM deployments.

Moreover, the study investigated that deposit ratio had positive and statistically significant impact on the deployment of ATM. This result is consistent with results investigated by (Yen, 2011). The implication is that banks with higher customer demand for deposit service tend to invest more on ATM because banks invest on modern technology particularly, ATM to increase customer satisfaction and thereby to attract deposits. In a nutshell, the implication of significant and positive coefficient of bank size, bank profitability and deposit ratio is that banks with higher total asset, profit and ratio of deposit have better Automated Teller Machine deployment. On the other hand, those banks with lower total asset, lower profit and lower ratio of deposit have small number of ATM deployment. However, cost efficiency and number of branches were statistically insignificant and were not considered as important determining factors of ATM deployment by Ethiopian commercial banks.

Based on the results investigated, we have forwarded the following policy implication and future research directions. The findings of this study suggested that Ethiopian commercial banks with lower ATM deployment should take action for better investment of ATM by increasing bank size, bank profitability and ratio of deposit. Future research will expand coverage by including other financial institutions to fully understand the ATM deployment in Ethiopia. Rigorous outlook shall be carried out to investigate the dimensions and determinants of ATM deployment in Woreda, Zone and Region level.

Declarations

Author contribution statement

Eshetie Woretaw Meried, Mahilet Demissie Adane and Teramaj Walle: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.
Additional information

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