Ownership and Bank Efficiency in Africa: True Fixed Effects Stochastic Frontier Analysis

Samuel Mutarindwa†  Ibrahim Siraj‡  Andreas Stephan§

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Abstract

This paper investigates the effects of ownership patterns on bank cost and profit efficiencies taking a sample of 607 commercial banks operating in 53 African countries during the period 2005-2015. Using pooled and modified true fixed effects (TFE) stochastic frontier panel approaches, we obtain two principal results. First, foreign-owned banks are more profit and cost efficient than their domestic peers. Second, privately owned banks outperform state-owned banks. These findings result not only from bank-level inefficiency but also from differences related to other bank- and country-specific factors. Specifically, larger, older, and listed banks with many years of operations in host countries are associated with higher cost and profit efficiency. This study also reveals that ownership concentration (blockholding) has adverse effects for the profit and cost efficiency of banks.

Key Words: ownership, blockholding, efficiency, stochastic frontier analysis, fixed effects

JEL codes: G21, G28, G30, G32, G38

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†Corresponding author: samuel.mutarindwa@ju.se, Jönköping University, Sweden; University of Rwanda

‡Ibrahim.Siraj@liu.edu, Long Island University-Post, USA

§andreas.stephan@ju.se, Jönköping International Business School, Jönköping University; Linnaeus University Växjö, and CESIS Stockholm, Sweden
1 Introduction

Banks perform vital functions in a country’s economic systems through their intermediation activities that, in turn, contribute to that country’s growth and development (Levine, 1997, 2005). This particularly holds for African countries where financial markets are less developed, making their banking systems important providers of financial services. In recent decades, the expanding entry of privately owned domestic banks, along with an increase in the number of foreign banks, has played a vital role in these economies. Although state-owned domestic banks have traditionally dominated Africa’s banking systems, some structural reforms are reversing this trend. Specifically, the implementation of structural adjustment programs (SAPs) has led to massive privatization of former state-owned domestic banks.¹

By 2010, the share of state-owned banks fell as low as an average of 8% in developing countries. The presence of foreign banks in Africa grew from 34% in 1995 to 66% in 2008 and to 73% in 2010 (Cull, Peria, & Verrier, 2017). Claessens and Horen (2014) report that in Sub-Saharan Africa, possibly as a result of the colonial history of the countries located in the region, foreign-owned banks controlled 31% of banking activities in 1995, with an increase to 51% by 2009. The important role played by banks in African economies implies that their efficiency and performance is crucial. This study investigates whether the profit and cost efficiency of banks operating in Africa has been improved by the transition in bank ownership from state-owned domestic to privately owned foreign banks.

Studies on the relationship between ownership and bank efficiency from the context of non-African regions are comprehensive (e.g., Basílio, Pires, & Reis, 2016; Berger, Klapper, & Udell, 2001; Claessens, Demirgüç-Kunt, & Huizinga, 2001; Hasan & Marton, 2003). A crucial issue of these studies is the use of appropriate methodology for measuring efficiency. Using stochastic frontier analysis (SFA) is a widely accepted parametric method of measuring efficiency. Prior literature that employed this method, however, faced the challenge of separating unobserved time-invariant bank heterogeneity from bank-level inefficiency.² Failure to capture this separation results in biased bank efficiency estimates. To address this issue, this study is the first to use the recently developed pairwise difference estimator (PDE) of Belotti and Ilardi (2018). This PDE addresses the inconsistency of maximum likelihood estimation in true fixed effects models when including time-invariant bank-specific heterogeneity. Our study focuses on two research

¹Enoch, Mathieu, Mecagni, and Kriljenko (2015) argue that the stability of countries in Africa, the end of apartheid in South Africa, regional integration and capital regulation policies, such as those found in Nigeria, have spurred the entry of foreign banks (primarily of a Pan African nature) into the banking systems of other African countries.

²See Greene (2005) and Chen, Schmidt, and Wang (2014) for a more detailed discussion on this issue.
questions: (1) How efficient are foreign-owned banks compared to their domestic counterparts operating in African countries? (2) How is bank efficiency affected by changes in ownership thresholds?

The results of the econometric estimations show that foreign-owned banks are relatively more profit and cost efficient than their domestic counterparts, and privately owned banks outperform state-owned banks. The superior cost efficiency of foreign-owned banks is mainly explained by their internal technical and allocative efficiency and also by other bank-level characteristics, reforms and macroeconomic conditions. Specifically, the efficiency of such banks improves when they are large, when they are listed on stock exchanges, and when they have been operating for a long time (age) in host countries with good economic conditions (growth rate and GDP per capita).

Another important question in the literature that is missing in the African context is how ownership concentration affects bank efficiency. Our findings show that the presence of controlling shareholders is detrimental to bank efficiency for all types of banks. Our study addresses another important issue. If domestic banks, both privately owned and state-owned, operate at high level efficiency, this might influence acquisition attempts by foreign or private investors. In this case, efficiency would determine ownership and not the other way around, leading to reverse causality and endogeneity. To address this issue, we use efficiency (cost and profit) scores from previous periods as the explanatory variables of probit models to predict ownership. Estimation results show that past levels of cost and profit efficiency are not suitable predictors of bank ownership, neither foreign nor private. This gives us confidence to draw causal inferences on the effects of ownership on banks’ cost and profit efficiency, rather than the other way around, that efficiency levels drive ownership changes.

This study revisits the connections between ownership and bank efficiency in African countries and contributes to a number of streams of empirical literature. First, it contributes to the comparative performance of domestic and foreign banks by revealing the mechanisms that drive these performance differences in African countries, an area that has seen little analysis in the empirical literature on bank efficiency. Previous studies have focused on developed, transitional and other developing countries with little coverage of African countries. In a review of 130 efficiency studies by Berger and Humphrey (1997), there is one African country study (Tunisia), and two studies that focused on determinants of efficiency other than bank ownership. Claessens and Van Horen (2012)’s review of 35 studies on bank performance and efficiency covers more developed countries with only 5% of the studies covering developing countries, and with no study focusing on an African country. In addition, the majority of previous studies measuring banking
efficiency focus on explanatory variables other than ownership. The few studies that examine bank ownership and efficiency in Africa mainly use a single-country approach. Essentially, our study expands on previous studies by using more recent data and a new state-of-the-art efficiency estimation approach.

Second, and related to the first contribution, our study contributes to the literature on the measurement of bank efficiency by specifically applying stochastic frontier analysis (SFA). The empirical literature on bank efficiency shows that a mix of different estimation techniques (both parametric and non-parametric) may yield mixed results (see Berger & Humphrey, 1997, for surveys on bank efficiency). The majority of studies using stochastic frontier approaches do not take into consideration the estimation problem that results from separating unobserved time-invariant bank-specific heterogeneity and bank-level inefficiency, and that can lead to biased efficiency estimates. Greene (2005) proposes true random or fixed effects SFA models that also allow for time variation of inefficiency. These models are able to disentangle the inefficiency estimate from bank-specific effects (random or fixed), which has been addressed in only a few previous studies on bank efficiency (e.g., Goddard, Molyneux, & Williams, 2014; Parinduri & Riyanto, 2014). Our study goes beyond these two studies by reconsidering the recent propositions of Belotti and Ilardi (2018) and Chen et al. (2014) on how to solve the incidental parameter problem inherent in Greene’s true fixed effects SFA model. Belotti and Ilardi (2018) address the problem of inconsistent estimates of the inefficiency variance if the time dimension \( t \) is fixed, as assumed by Greene’s maximum likelihood estimator, for the true fixed effects model. They propose an estimator that eliminates the noise of firm specific heterogeneity through data transformation, and then perform maximum likelihood estimations. To the best of our knowledge, this study is the first application of Belotti and Ilardi’s (2018) approach to the African banking industry using the Pairwise Difference Estimator (PDE) which addresses the incidental parameter problem. Recently, Damoah (2017) used this estimator in a different context for a sample of manufacturing firms in Ghana.

Third, the current study contributes to the strand of empirical literature on corporate governance of banks by assessing the effects of controlling shareholders on bank performance (Busta, Sinani, & Thomsen, 2014; Haw, Ho, Hu, & Wu, 2010; Migliardo & Forgione, 2018). While it is true that a majority of these studies cover banks from developed countries, Ozili and Uadiale (2017) examine the relationship between bank profitability and ownership in Nigeria. We empirically extend this study by providing cross-country

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3For example, Hauner and Peiris (2008) and Mlambo and Ncube (2011), both assess the effects of competition on banking efficiency in Uganda and South Africa, respectively.

4For example, Bokpin (2013), Beck and Hesse (2009), Beck, Cull, and Jerome (2005) use single country bank samples (Ghana, Nigeria, and Uganda, respectively) to study the effects of ownership and market power on bank efficiency, while we exploit a cross-country panel. Figueira, Nellis, and Parker (2006) also use a cross-country sample of bank data, but they employ a cross-sectional research design.
evidence on how banks’ cost and profit efficiency behave when blockholding exceeds a certain threshold.

The paper is organized as follows: Section 2 reviews the related literature and develops propositions. Section 3 presents data and measurement of variables. The description of our empirical methodology and the results are described in Section 4, while Section 5 concludes.

2 Literature review and propositions

2.1 Ownership and bank efficiency

Previous studies have extensively assessed the impacts of ownership on bank efficiency using single and cross-country bank samples, with the majority of them covering specific contexts including: transitional countries of Europe (Bonin, Hasan, & Wachtel, 2005; Fang, Hasan, & Marton, 2011; Fries & Taci, 2005; Weill, 2003), emerging economies of Asia, Latin America and Europe (Berger, Clarke, Cull, Klapper, & Udell, 2005; Berger, Hasan, & Zhou, 2009; Hasan & Marton, 2003), high income countries (Berger et al., 2001; Chang, Hasan, & Hunter, 1998), country comparisons of Portugal and Spain (Bas’ilio et al., 2016), and a few international studies of developing and developed countries (Claessens et al., 2001).

The studies are centered around two differing viewpoints. The global advantage hypothesis strand of bank efficiency literature proposes that relative to domestic private and domestic state-owned banks in host countries, foreign-owned banks have superior technology and scale economies, as well as better corporate governance and financial power offered by their parent bank headquarters providing them with increased efficiency (Berger et al., 2005; Berger, DeYoung, Genay, & Udell, 2000). The second strand, known as the distance or home advantage hypothesis (Berger et al., 2005, 2000; Lensink, Meesters, & Naaborg, 2008), suggests that the distance between host and home countries affects the operations of foreign banks. Distance may cause information asymmetries when working in new markets, difficulties in establishing relational networks and poor knowledge of local conditions, including: culture, language, local politics and institutional dynamics.

Overwhelmingly supporting the global advantage hypothesis, a dominant finding of these studies are that foreign-owned banks in developing countries are more efficient (e.g., Berger, Hasan, & Klapper, 2004; Berger et al., 2009; Bonin et al., 2005; Claessens et al., 2001). Empirical evidence suggests, however, quite the opposite for the performance

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5One of the most comprehensive study is Claessens et al. (2001) where an international sample of 7,900
of state-owned banks. La Porta, Lopez-de Silanes, and Shleifer (2002) argue that state-owned banks can become vehicles to achieve political goals. Being used in this way might be more prevalent in developing countries with poor property rights and politically motivated lending policies (Carvalho, 2014; Claessens, Feijen, & Laeven, 2008; Dinç, 2005; Sapienza, 2004). Even when compared to privately owned local banks, state-owned banks exhibit worse performance in profitability and cost management (Micco, Panizza, & Yanez, 2007), inadequate holding of capital and higher credit risk (Cornett, Guo, Khaksari, & Tehranian, 2010), and lower efficiency (Fries & Taci, 2005). In short, the empirical literature overwhelmingly identifies state-owned banks as the least efficient and giving the worst performance when compared to privately owned and foreign-owned banks.

2.2 Bank ownership and efficiency in the African region

Several unique aspects of the economies of African countries make the issue of the efficiency of its banking sector quite important. Considered to be the poorest continent, Africa has a long way to go to improve its financial sector. For example, Sub-Saharan Africa, which is the poorer part of the continent is projected to be home to up to 87% of the world’s extreme poor by 2030 (WorldBank, 2018). In 2011, this region of Africa had a median deposit to GDP ratio of only 25% and a median private credit to GDP of only 18% (Beck & Cull, 2013). These ratios are significantly lower than for comparable countries outside of Africa. Beck and Cull (2013) argue that African banks have more expensive and less efficient financial services than banks in other developing parts of the world. While dominated by state-owned banks in the 1980s, the African banking sector experienced a significant shift in the ownership structure following the privatization wave in the 1980s and 1990s, with an upsurge in foreign ownership. Given this dramatic shift, surprisingly few studies focus on the relationship between ownership and bank efficiency from 80 host countries is used. The paper finds that foreign banks are more efficient (net interest margins, overheads, tax and profits) compared to domestic banks, and that this result is more pronounced in developing countries than in developed ones. They also find that foreign banks adversely affect domestic banks’ profits because the presence of foreigners increases competition. Berger et al. (2000) obtain similar findings when studying the link between bank ownership and efficiency in France, Germany, Spain, the United Kingdom and the United States. However, domestic banks performed better in those countries than foreign-owned banks (cost and profit efficiency).

6Besides the politically motivated reasons, the principal-agent problem is likely to be more severe in state-owned banks (Huibers, 2005) Additionally, state-owned institutions are often associated with conjectures like the “quite life” hypothesis, “too big to fail”, and weak monitoring and disciplinary pressure (Megginson, 2005).

7However, the findings of the literature are not all about inefficiency associated with state ownership. For example, using a sample of Chinese banks, Jiang, Liu, and Molyneux (2019) show that state-owned banks are efficient in capital adjustment, which supports the “development” view hypothesis that government owned banks act on long-term oriented goals for the development of the society.
in African countries.\textsuperscript{8} Beck et al. (2005) examine the privatization of banks in Nigeria and find that this process improved the performance of fully privatized banks, but had an adverse effects on the performance of banks still under partial government ownership.\textsuperscript{9}

### 2.3 Propositions

Based on previous findings, we can propose that foreign-owned banks operating in Africa will have a superior performance. Therefore, our first proposition is that there should a positive relationship between bank efficiency and foreign ownership.

We argue that the institutional features of a country will play an important role in this relationship. Using a sample of 2095 commercial banks from 105 countries, Lensink et al. (2008) find that bank efficiency is affected by institutional quality of both the host and home countries. Banks in well governed countries have higher efficiency scores. Prior research also identifies that foreign-owned banks experience higher efficiency in host countries that maintain better creditor rights (Kalyvas & Mamatzakis, 2017) and allow for higher financial freedom (Lin, Doan, & Doong, 2016). When the home countries of foreign-owned banks are more developed than the host countries, and the host countries’ regulations are weak, the foreign-owned banks exhibit higher levels of efficiency than domestic banks. Another favorable condition for foreign-owned banks is when both host and home countries have similar languages (Claessens & Van Horen, 2012). Therefore, our next proposition is that the positive relationship between bank efficiency and foreign ownership will be positively influenced by institutional development of the host countries.

Finally, we argue that ownership concentration will play an important role in the relationship between ownership and efficiency. Fama and Jensen (1983) postulate that firms with dispersed shareholders have agency problems because it is more difficult to mon-

\textsuperscript{8}In a single country study Bokpin (2013) finds that foreign-owned banks outperform domestically owned banks in Ghana in terms of lowering costs, but not in terms of improving profits. On the other hand, in a study for Uganda, Beck and Hesse (2009) show that there was no efficiency improvement associated with the privatization of former state-owned enterprises, or with the entry of foreign-owned banks. Figueira et al. (2006) study bank performance and efficiency using a cross-section of 340 commercial banks drawn from 40 African countries. Combining traditional performance measures and efficiency techniques (both parametric and non-parametric), they find that state-owned banks are more efficient than privately owned domestic and foreign-owned banks. Stochastic frontier analysis results for this study do not show a similar difference.

\textsuperscript{9}There are important studies that examine the effects of privatization programs on bank performance in non-African countries. Berger et al. (2005) find non-performing loans were higher among state-owned banks. They also find that state-owned banks persistently performed poorly when compared to banks that were either fully privatized or undergoing privatization. Looking at a more detailed breakdown of bank ownership after privatization in transition economies, Fries and Taci (2005) find that privately owned banks are more efficient than state-owned banks, and that privatized banks with majority foreign ownership are the most efficient. Cheng, Zhao, and Lin (2017) examine post-privatization behavior of banks in China (efficiency, profitability and credit risk). They reveal that post-privatized banks improve their efficiency, profitability and lower credit risk when acquired by foreign strategic investors soon after acquisition.
itor the activities of managers. This problem can be mitigated by blockholders. However, blockholders may create another agency problem by expropriating shareholders who hold minority interests in the firm. Overall, cross-country evidence suggests that ownership concentration reduces non-performing loans and improves capital ratio in countries with strong supervisory controls and shareholder protection laws (Shehzad, De Haan, & Scholtens, 2010), improves loan quality and lowers both credit and insolvency risks (Iannotta, Nocera, & Sironi, 2007), and increases profit efficiency and lowers risk taking of banks (Migliardo & Forgione, 2018). Ozili and Uadiale (2017) is the only paper that examines the issue of bank ownership concentration in an African setting. Focusing on Nigeria, they find that blockholding relatively improves the return on assets, return on equity, net interest margins and banks’ earning power. Building on this literature, our final prediction is that closely held banks are likely to outperform their widely held counterparts in African countries.

3 Empirical approach

3.1 Data sources

Bank-level financial information is collected from Bureau van Dijk’s Bankscope database. The sample includes domestic (private and state-owned) and foreign (private and state-owned) commercial banks operating in 53 African countries during the period 2005-2015. Ownership data is collected from Bankscope and from Claessens and Van Horen (2015). In cases where these sources do not provide complete information on ownership, we manually collect data from banks’ annual reports published on their websites. Information on countries’ institutional and macroeconomic variables are obtained from the World Bank’s website.

3.2 Measurement of bank efficiency

Bank efficiency studies typically measure efficiency using either non-parametric or parametric approaches, or both. Methods using non-parametric approaches, such as Data Envelopment Analysis (DEA), involve the use of mathematical programming tools to construct efficiency frontiers (S. Yildirim & Philippatos, 2007) and do not deal with any functional forms or error terms (Berger & Humphrey, 1997; Zajc, 2006). In contrast, Stochastic Frontier Analysis (SFA) is a parametric frontier technique that assumes a functional form and a distinction of random errors from inefficiency in either production, cost or profit functions (Aigner, Lovell, & Schmidt, 1977). Our study focuses only on profit and cost efficiency of banks and uses the SFA approach that is well suited to our panel
3.2.1 Stochastic Frontier Analysis (SFA)

Aigner et al. (1977) and Meeusen and van Den Broeck (1977) first introduced the idea of SFA that uses a random idiosyncratic component and an inefficiency component as the two parts of a compounded error term in a production function. Subsequently, a significant number of studies have continued to develop this idea and expand it to include the panel version of SFA models.\(^{10}\) The basic structure of the model in the context of a bank efficiency panel setting is as follows:

\[
\ln q_{it} = x_{it} \beta + E_{it} \tag{1}
\]

where \(q_{it}\) is output in log form, \(\beta\) is the parameter vector of inputs used by banks \(i = 1 \ldots , N\), time \(t = 1 \ldots , T\), and \(E_{it}\) denotes the error term which is decomposed as:

\[
E_{it} = v_{it}(+-)u_i. \tag{2}
\]

\(v_{it}\) is a time-variant random error representing noise or measurement errors resulting from uncontrollable factors. It is assumed to have a standard normal distribution with mean 0 and standard deviation \(\sigma_v^2\). The inefficiency term \(u_i\) is a time-invariant and firm-specific parameter related to controllable factors such as managerial efficiency, and is expressed as either a random or fixed effect. It is assumed to follow a truncated normal distribution having non-negative values,

\[
u_{it} \sim N^+(0, \sigma_u^2) \quad \text{and} \quad v_{it} \sim N(0, \sigma_v^2). \tag{3}\]

Another group of papers incorporated the time-varying feature of inefficiency into SFA panel models (e.g., Battese & Coelli, 1992, 1995; Kumbhakar & Lovell, 2000). The early models, however, treat the time-variant heterogeneity of individual units as a part of the inefficiency term. In other words, bank-specific unobserved heterogeneity is considered to be part of the inefficiency term \((u_i)\), which might produce a biased estimate of inefficiency confounded with bank fixed effects. Greene (2005) attempts to overcome this estimation issue by introducing the true effects approach for stochastic frontier models. A true effects model differentiates the inefficiency term (which varies over time) from the bank-specific unobserved heterogeneity (which does not vary over time). Greene suggests

\(^{10}\)Kumbhakar and Lovell (2000) and Greene (2008) provide detailed accounts on how the basic structure of SFA models has developed over time.
that the part of the model which does not change over time is the specific idiosyncrasy of
the firm, which should be differentiated from the inefficiency part that varies with time. Greene (2005) further distinguishes between true random effects (TRE) and true fixed
effects models (TFE) to draw similarities with the conventional fixed effects and random
effects. A true fixed model is written as:

$$\ln y_{it} = \alpha_i + \beta x_{it} + E_{it}$$ (4)

where \( y_{it} \) is the output in log form, \( \alpha_i \) is bank fixed effect measuring firm-individual
time-invariant characteristics, \( \beta \) is the parameter vector of inputs used by banks \( i = 1 \ldots, N \)
in time \( t = 1 \ldots, T \), \( E_{it} \) denotes the error term which is decomposed as:

$$E_{it} = v_{it}(-+)u_{it}.$$ (5)

where the distributions of \( v_{it} \) and \( u_{it} \) are as before\(^{11}\)

$$u_{it} \sim N^+(0, \sigma^2) \quad \text{and} \quad v_{it} \sim N(0, \psi^2). \quad (6)$$

These two types of errors are independent from \( \alpha_i \), rendering \( \alpha_i \) to be treated as an individual bank-specific fixed effects, which are estimated as parameters (Chen et al., 2014). Other regressors are included in the estimation of the frontier as they may account for differences in these inefficiency estimates.

### 3.2.2 Model specification

Our study follows Greene (2005)’s proposition of disentangling bank specific heterogeneity from the inefficiency term, and adopts recent propositions in Belotti and Ilardi (2018), Chen et al. (2014), and Kumbhakar and Tsionas (2011) that emphasize efficiency estimation issues (incidental parameter problem) embedded in fixed effects SFA models. According to Greene (2005), firm-specific effects or heterogeneities should be separated from the inefficiency term by using dummy variables that can be estimated using the so-called Maximum likelihood dummy variables estimator (MLDVE). Chen et al. (2014) argue that the parameter estimation becomes inconsistent if the number of panel units tends to infinity while time is fixed, which is what causes the incidental parameter problem.\(^{12}\) Belotti and Ilardi (2018) build on this work and propose two estimation techniques that produce maximum likelihood consistent estimates to address the problem in the TFE

\(^{11}\)Note that the model becomes a stochastic cost frontier when the sign of \( u_{it} \) is positive.

\(^{12}\)Even in the presence of \( n \), the usual results of asymptotic properties may not apply since fixed effects parameters increase with \( n \), which creates uncertainty in achieving consistency in estimating the parameters.
model. The first model is the marginal maximum simulated likelihood estimator (MMSLE), and the second is the pairwise difference estimator (PDE). In the latter, variables are transformed to remove fixed effects that would cause the incidental problem. The first step in the PDE or MMSLE is to transform the equation to the first difference to eliminate the nuisance parameters. Following Belotti and Ilardi (2018, p.162), this can be written as:

\[ \Delta y_i = \Delta X_i \beta + \Delta \tilde{e}_i \]  \hspace{1cm} (7)

\[ \Delta \tilde{e}_i = \Delta \nu_i - \Delta u_i. \]  \hspace{1cm} (8)

\[ \Delta \nu_i \sim N_{T-1}(0, \psi) \]  \hspace{1cm} (9)

\[ \Delta u_i \sim \chi^2(\sigma), \]  \hspace{1cm} (10)

where \( \Delta y_i = (\Delta y_{i2}, \ldots, \Delta \ln y_{iT}) \) for \( \Delta y_{it} = y_{it} - y_{it-1} \). The term \( \Delta X_i \) denotes the matrix of varying covariates for which \( t \)th row is given by \( \Delta X_{it} = (\Delta X_{iit2}, \ldots, \Delta X_{itk}) \), \( \forall t = 2, \ldots, T \).

Step two involves maximum likelihood estimation using the transformed model in Equation (7) employing either the Marginal Maximum Likelihood Estimator (MMSLE) or the Pairwise Difference Estimator (PDE) adopted in this study. In the empirical estimation, we specify a translog cost/profit function as shown below:

\[ \log \text{Frontier}_{it} = a_i + \gamma \ln Y + \sum_{j=1}^{2} \beta_j \ln X_{ijit} + \sum_{t=2005}^{2015} \lambda_t \delta_t + E_{it} \]  \hspace{1cm} (11)

where \( \log \text{Frontier}_{it} \) denotes the log of either total costs or of profits, and \( X_{ijit} \) denotes the inputs and outputs relevant for total costs described in Subsection 3.2.3 below. In this model, the inefficiency term \( u_{it} \) is assumed to be exponentially distributed. Further, for the PDE model to consistently estimate ML, based on the inefficiency term \( u_{it} \), a heteroskedastic element is introduced to allow the scale parameter to vary with covariates and with time, denoted as:

\[ \sigma_{it} = \exp(z_{it} \gamma), \]  \hspace{1cm} (12)

where \( z_{it} \) is a composite of the covariates which may or not vary with time, including ownership variables, listing, bank size and macroeconomic variables.

\[ \text{The baseline equation to be transformed is similar to Greene (2005)’s equation where the error term } \nu_{it} \text{ follows a normal distribution with mean 0 and variance } \sigma^2. \text{ The distribution of the inefficiency term } u_{it} \text{ is independent from the random error term and follows a density (f) distribution whose parameter is scaled } \sigma^2_{u}. \]
3.2.3 Definition of costs, profits, outputs and inputs

For the empirical specification of a bank production function, we adopt an intermediation approach assuming that banks employ labor and capital to transform the collected deposits into loans. Based on this approach, we follow previous studies to determine inputs and outputs in the empirical models (Bonin et al., 2005; Cornett et al., 2010; Hasan & Marton, 2003; Lin et al., 2016). We use three inputs: the prices of physical capital, borrowed funds and labor. The price of physical capital denoted as \( \log(\text{Price of capital}) \) is measured by overhead costs scaled by fixed assets. The price of borrowed funds denoted as \( \log(\text{Price of funds}) \) is interest expenses scaled by customer deposits and short-term borrowing. Bankscope does not readily provide the cost of employees which is the proxy for price of labor. We follow Lin et al. (2016) in computing the price of labor. It is computed as non-interest expenses over total assets and is denoted as \( \log(\text{Price of labor}) \). Two main outputs are used: the quantity of loans denoted as \( \log(\text{Loans}) \), and the quantity of total earning assets denoted as \( \log(\text{Total earning assets}) \). Outputs are measured in dollar values for which data is readily available in Bankscope. We also define total cost denoted as \( \log(\text{Total cost}) \) which is the sum of overheads and loans loss provisions (LLP). Bankscope does not provide readily available data for both interest and non-interest expenses. We use LLP as interest expenses and total overheads as non-interest expenses. Finally, we define profit, denoted as \( \log(\text{Profits}) \) as profit before tax.

3.3 Measurement of ownership

We use several proxies to measure bank ownership. The first proxy for bank ownership is ownership concentration. This variable measures the size of shareholding by the blockholder(s). To capture the differences in blockholding, ownership concentration is measured in terms of quartiles where the categorial variable \textit{Quartile} has value 1 if shareholding is 1-25%; value 2 for 26-50%; value 3 for 51-75%; and value 4 for 76-100% shareholding. For the origin of bank owners, we use the definition provided by Claessens and Van Horen (2015) and Allen, Jackowicz, Kowalewski, and Kozłowski (2017) on foreign and domestic bank ownership. A bank is foreign-owned if at least 50% of shareholding is owned by foreign individuals or entities. A dummy variable \( \text{Foreign} \) is used that takes the value of 1 if a bank is foreign-owned and 0 for domestically owned banks. In addition, following Hasan and Song (2012), the dummy variable \( \text{Stated-owned} \) indicates state-owned banks with a value of 1 and private ownership with value 0. Finally, we use five regional classification to describe the majority foreign ownership: Asian, European, Middle East, Pan African, and the US. Table 1 provides the detail of the definition of each of the regions.
3.4 Controls

We use several bank-level controls to explain the bank cost and profit inefficiency frontiers. We control for Size, as measured by total assets in US Dollars expressed as a natural logarithm denoted as Log (Total assets). The age of the bank (Age) is captured by the number of years a bank has been in operation in a certain country since its incorporation or registration. Because variable Age is skewed, we use Log (Age). We also control for stock market status by including Listed as a dummy variable with a value of 1 if a bank is listed on a stock exchange market and 0 otherwise. Finally, we control for macroeconomic conditions using Growth rate and Log (GDPpercapita). Variable Growth rate is winsorized at 1 and 99% to reduce the impact of extreme observations.

4 Results

4.1 Descriptive results

Table 2 summarizes descriptive results for the variables used in the frontier analysis. In Panel A, we can observe that Log (Profits) and Log (Loans) have relatively higher standard deviations than other variables. For other bank level variables, Panel B shows that 17% of the banks participate in stock markets, while the average age of a bank in operations is 28 years. For country-level variables, Panel C indicates that the annual growth rate is 4.53%, and Log (GDPpercapita) is on average 7.1.

Table 3 shows that state-owned constitute 16% of the entire bank sample (both foreign and domestic), while 84% privately owned banks. Foreign-owned banks contribute, on average, to 56% of the banks in the sample, indicating the dominance of foreign ownership in the banking sector of the African region. In the regional distribution, Pan African banks (22%) and European banks (14%) hold a sizable portion of total banks in Africa. Importantly, we observe that 58% of our bank sample is held by large shareholders, who hold between 76% and 100% shares of a bank.

Table 4 presents the distribution of ownership variables by country during the period of 2005-2015. Results show heterogeneities in size, origin and type of bank ownership across countries. We see that countries with the largest economies, such as Egypt, Kenya, Ghana, Mauritius, Nigeria, South Africa and Tanzania, have a large number of banks. In
contrast, countries with small economies, such as Central African Republic, Comoros, Eritrea, Equatorial Guinea and Guinea Bissau are represented in the sample by not more than two banks. If we examine ownership type, we see that the majority of the countries in our study have banks that are privately owned. Only a few North African countries, like Libya and Sudan, have state-owned banks, implying that countries have over time relinquished government ownership of banks. When we determine the origin of banks, Ethiopia and Eritrea are exclusively dominated by domestically owned banks, while the majority of other countries have many foreign-owned banks in operation. Kenya, Nigeria, and South Africa have a large share of domestically owned banks, but also have banks operating in many other African countries in the form of Pan African banks. This finding corroborates Enoch et al. (2015) who suggest that big South African banks opened up to the rest of African countries after the apartheid era. Nigerian banks entered other African foreign markets after the central bank of Nigeria (CBN) raised minimum capital requirements for commercial banks operating in Nigeria, while regional integration helped Kenyan banks expand to other East African countries. Uganda, Tanzania, Democratic Republic of Congo show an increase in foreign bank entry over time.

[Table 4 here]

Table 4 also shows the types of variations underlying our sample dataset. Relative to high variations of the variables in the overall sample and between banks, we observe a significantly smaller variations of variables within the banks throughout the years.\textsuperscript{14} For example, variables such as ownership (Foreign and State-owned) and Listed seem to change in a negligible manner over time. To explore this relationship more deeply, we use two types of models in our estimations: (1) a pooled cross-section of the SFA model which allows for identification of the effect of variables with small within-bank variation and (2) a modified TFE model. Estimating panel SFA TFE models using the PDE may partially eliminate the effect of those fairly persistent variables on efficiency due to the included fixed effects.

The histogram (1) reports the mean technical efficiency scores for banks in terms of costs and profits in which the efficiency models estimated are assumed to be exponentially distributed.\textsuperscript{15} The largest group of banks in the sample is 75% efficient with a standard deviation of 16%. The most efficient banks have efficiency scores close to the efficient frontier (99%), and the least efficient have efficiency scores as low as 0.16%.

[Figure 1 here]

\textsuperscript{14}Note that the within-bank variation of variables is not reported in Table 4 but is defined as the difference between overall and between variation.

\textsuperscript{15}Note that technical efficiency is derived from the inefficiency estimates $\hat{u}_t$ as $TE = \exp(-\hat{u}_t)$. 

13
4.2 Results from regressions

Table 5 reports results for two types of models, namely the pooled cross-section and the PDE estimator for the TFE panel model. The first two columns report results for the pooled models. Results for cost efficiency estimations using pooled estimations did not converge, so only profit efficiency is estimated. Columns 3 through 5 report results for the panel estimations (TFE) for both cost and profit efficiency. The coefficients for the inputs and outputs in both pooled and panel estimations are in line with expectations as most of the coefficients are significant at 1%. Inputs show significant negative signs with profits and significant positive signs with total costs. In the lower part of Table 5, we report $\bar{\sigma}$, which is the estimated scale parameter of technical inefficiency $\eta$, and $\psi$, which denotes the standard deviation of the idiosyncratic error component. We find that $\psi$ significantly decreases once fixed effects are considered, thus showing the relevance of using the TFE panel model. We also find that the average of estimated bank profit inefficiency decreases from 0.73 to 0.47 in the TFE model, similarly the standard deviation of estimated bank-level inefficiency decreases from 0.65 to 0.54, again confirming that the chosen TFE models are an improvement to the cross-sectional SFA models.

Note that a negative coefficient implies that the respective variable reduces the heterogeneity of inefficiency, and by this also lowers average inefficiency. Column 1 of Table 5 therefore indicates that foreign-owned banks are associated with higher profit efficiency compared to their domestic counterparts. This finding concurs with previous studies. For instance, Berger (2007) also argues that the ability of foreign-owned banks to diversify risks in different countries and regions could raise their profit levels. Findings from our study also concur with results obtained in previous studies covering transition countries, such as Fries and Taci (2005) who compare the efficiency of foreign and domestic banks in post-Communist countries, Bonin et al. (2005) who analyze 11 transition countries and Greene (2005) who investigates 17 countries. The superior performance of foreign-owned banks vis-a-vis their domestic counterparts may be explained in part by their comparative advantage when it comes to technology, financial experiences in areas of risk management and information technology that they import to host countries’ banking systems. This subsequently improves their efficiencies (Berger et al., 2000). Fang et al. (2011) suggest that the superior performance of foreign-owned banks could partly be explained by selection issues, implying that these banks tend to acquire domestic banks that are performing well. The coefficients are negative and highly significant in all models implying that there are learning effects associated with the time the banks have been in operation. The results for our country-level variables show that the level of economic development denoted as $\log (\text{GDP per capita})$ significantly increases both profit and cost efficiencies in both cross-section and the PDE models.
Results also show that state-owned banks in the sample are significantly less profit efficient in all models. Columns 3 through 5 of the same table show results for TFE models produced using the PDE for both profit and cost efficiency. Results show that state-owned banks are associated with lower profit efficiencies than privately owned banks and are marginally less cost efficient. Previous studies with similar results suggest that state-owned banks invest less time and monetary efforts in monitoring loans given to customers, subsequently producing higher non-performing loans and a lower return on investment (Berger et al., 2009).

Bank-level controls do significantly improve banks’ profit efficiency, and in some cases improve cost efficiency also. Specifically, listing improves the profit efficiency of banks. Berger et al. (2009) argue that stock exchanges (especially new investors) exert pressure on managers of listed banks to increase bank value and to enhance the transparency of their financial records, which improve governance and bank efficiency. Larger banks are associated with higher profit efficiency and lower cost efficiency, which may result from economies of scale given higher diversification abilities of larger banks. The superior efficiency of larger banks may also result from managerial experience, as they tend to hire highly experienced and seasoned managers. In addition, age matters for both profit and cost efficiency of banks across all models. The coefficients are negative and highly significant in all models, implying that there are learning effects associated with the time the banks have been in operation. Regarding country-level variables, results show that the level of economic development denoted as Log(GDPpercapita) significantly increases both profit and cost efficiencies in both cross-section and PDE models. Annual growth rates only significantly improve banks profit efficiencies. The effects on cost efficiency are marginal with negative signs.

[Table 5 here]

The results related to the effect of controlling owners’ regions of origin on banks’ cost efficiency are reported in Table 6. Columns 1 through 3 report results for profit efficiencies with respect to the region of origin of majority shareholders. Banks with controlling shareholders originating in Africa, especially Pan African and regional banks (banks whose majority shareholders come from the same region as the host countries of operation), are less profit efficient. The coefficients for Pan African banks and those of regional banks are significantly positive, implying higher inefficiencies. In contrast, banks whose majority shareholders are headquartered in the US are associated with higher profit efficiencies. Those of Asian or European origin do have significantly higher profit efficiencies. In these estimations, both bank-level and country-level control variables

\[^{16}\text{Note that our results here signify the recent evidence in the literature that argues that the sources of for-}\]
are very significant and negative throughout all models, implying that these variables, in addition to ownership, explain higher profit efficiencies. Specifically, Table 6 shows that listed, older and larger banks improve profit efficiency in the sample studied. The level of a country’s economic development and positive growth rates also improve the efficiency levels of banks (profit and cost).

[Table 6 here]

Table 7 reports results on the effects of different levels of controlling ownership in banks using quartiles as measures of blockholding. Blockholding adversely affects banks’ profit efficiencies. Results are similar to those obtained by Haw et al. (2010) investigating a European sample. They conclude that their findings are as a result of managerial inefficiencies given higher levels of shareholder control, and from relational lending, which raises operational expenses. The size, age and listing of the banks, and our macroeconomic variables improve profit efficiency in the cross-section and TFE models.

[Table 7 here]

4.3 Endogeneity tests

The previous sub-sections report results for the effects of ownership characteristics (domestic, foreign, private and state ownership) on banks’ efficiency. There is a possibility that foreign-owned banks acquire the most efficient domestic banks, and that private owners acquire the most efficient state-owned banks. Under such circumstances, higher bank efficiency of domestic or state-owned banks may lead to acquisition by foreign and private investors leading to reverse causality, which may render the results invalid. In one previous study examining bank efficiency in transition countries, Fang et al. (2011) find that foreign-owned banks were more efficient than domestically owned banks and they suggest that this could be explained by situations in which foreign-owned banks acquire the best performing domestic banks. Our study addresses this endogeneity concern by predicting bank ownership characteristics and listing with bank efficiency estimates (as independent variables) to investigate whether foreign and private owners observe bank cost and profit efficiency over three years before they take on such banks, and whether the listing process is influenced by the efficiency of banks during a period of three years before listing. Results show that neither cost nor profit efficiency leads foreign banks
to acquire domestic ones, nor does it influence private owners to acquire state-owned banks. Results are also insignificant for listing. These findings show that endogeneity is not a severe issue in our current study. One potential explanation for these results is that the majority of foreign-owned banks enter host African countries as subsidiaries or branches. Results also show very little variation in the change from state-owned to private banks, implying that the majority of the private banks are incorporated as green-field banks (in case of domestic banks) and also as subsidiaries and branches of foreign private banks.

5 Conclusions

The empirical literature dealing with the effects of ownership on bank efficiency has for the most part, covered developed, transitional and emerging economies, but has given little attention to banking sectors of African countries. This paper attempts to close this gap by empirically investigating the effects of ownership (origin and type) on banks’ profit and cost efficiency using both pooled and a modified true fixed effects SFA models applying the pairwise difference estimator to avoid estimation bias (the incidental parameter problem). We use a sample of 605 banks located in 53 African countries. Results show that foreign-owned banks are associated with higher profit efficiency, but are not significantly more cost efficient compared to domestically owned banks. In addition, banks that are state-owned show lower profit and cost efficiencies. Findings also indicate that controlling shareholding thresholds have adverse effects on the profit efficiency of banks. Finally, going public (i.e., listing) and age improve the profit and cost efficiency of larger banks, specifically in favorable economic environments with higher growth rates. The main conclusion from these results is that bank ownership is a necessary but not sufficient condition for improving bank efficiency in Africa. Bank-level variables and country-level variables amplify the effects of ownership on bank efficiency. These findings have important policy implications. Relinquishing government ownership and allowing entry of foreign banks prove to be very important for improving both profit and cost efficiency. Equally, African banks represent higher levels of controlling shareholders which produce negative effects on both cost and profit efficiency of the banks operating in those countries. Going public could help banks overcome these deficiencies since our findings show that listing significantly improves the efficiency of banks. Future research on this topic could expand on our main findings by exploring how different ownership types impact bank stability.

17Endogeneity tests are not shown in the main document. They can be obtained upon request.
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Appendices

Tables
### Table 1: Variables description

| Variable              | Descriptions                                                                 | Source |
|-----------------------|------------------------------------------------------------------------------|--------|
| **Output-input variables:** |                                                                              |        |
| Log (Loans)           | Value of total loans to customers at the end of the financial year expressed in logarithm form. | (a)    |
| Log (Price of capital)| Overheads/Fixed assets*100 expressed in logarithm form.                       | (a)    |
| Log (Price of funds)  | Interest Expense on Customer Deposits / Average Customer Deposits expressed in logarithm form. | (a)    |
| Log (Price of labour) | Non-interest expenses/Total assets*100 expressed in logarithm form.            | (a)    |
| Log (Total assets)    | Measure of the size of the bank expressed in logarithm form.                  | (a)    |
| Log (Total cost)      | Loans Loss Provisions (LLP) +Overheads.                                       | (a)    |
| Log (Total earning assets) | Total earning assets to total assets expressed in logarithm form.   | (a)    |
| **Other bank-level variables:** |                                                                              |        |
| Age                   | Years of bank operation since date of establishment.                         | (a)    |
| Asian bank            | A binary variable indicating the bank is licensed to operate in African countries but whose main (majority) shareholder is incorporated in Asia. | (b)    |
| European bank         | A binary variable indicating the bank is licensed to operate in African countries but whose main (majority) shareholder is incorporated in Europe. | (b)    |
| Foreign               | A binary variable taking the value of 1 for foreign-owned banks and 0 for domestically owned banks. | (b)    |
| Listed                | A binary variable with 1 for listed banks and 0 for unlisted banks.           | (a)    |
| Middle East bank      | A binary variable indicating the bank is licensed to operate in all African countries but whose main shareholder is incorporated in Middle Eastern region. | (b)    |
| Pan African bank      | A binary variable indicating a bank whose major shareholder operates branches and subsidiaries in 10 or more African countries, outside the home country of incorporation which is also in Africa. | (b)    |
| Regional bank         | A binary variable indicating a bank whose major shareholder operates branches and subsidiaries in the region outside host country | (b)    |
| State-owned           | A binary variable with 1 for state-owned bank; 0 for private-owned banks.     | (b)    |
| Quartile              | A categorical variable taking values from 1 to 4 indicating the extent of to which shareholder(s) control the bank. Values defined based on quartiles: 1: quartile 1-25%; 2: quartile 26-50%; 3: quartile 51-75%; 4: quartile 76-100% ownership share. | (b)    |
**Variable** | **Descriptions** | **Source**
--- | --- | ---
US bank | A binary variable indicating the bank is licensed to operate in African countries but whose main shareholder is incorporated in the USA. | (b)

**Country-level variables:**
- **Growth rate**
  - Annual economic growth rate in percentage terms. | (c)
- **Log (GDP per capita)**
  - Logarithm of GDP per capita expressed in US Dollars. | (c)

Notes: Sources (a1): Bankscope (BvD) Database; (b): Bankscope + Datastream Database +Annual reports + Claessens and Van Horen (2015); (c): World bank (World Development Indicators)
| Variable | Panel A: Total costs, profits, inputs and outputs | Mean | Std. Dev. | Min | Max |
|----------|------------------------------------------------|------|-----------|-----|-----|
| Log(Profit) | overall | 9.59 | 1.94 | -0.29 | 14.73 |
| | between | 1.95 | 6.10 | 12.03 | |
| | within | 0.58 | 2.43 | 14.9 | |
| Log(Total cost) | overall | 10.22 | 1.69 | 2.43 | 15.31 |
| | between | 1.57 | 7.16 | 12.79 | |
| | within | 0.45 | 2.43 | 14.9 | |
| Log(Loans) | overall | 12.48 | 2.04 | 1.78 | 17.81 |
| | between | 1.95 | 4.63 | 17.41 | |
| | within | 0.59 | 4.97 | 15.54 | |
| Log(Total earning assets) | overall | 13.12 | 1.93 | 5.02 | 18.61 |
| | between | 1.84 | 8.21 | 15.5 | |
| | within | 0.46 | 6.1 | 15.4 | |
| Log(Price of funds) | overall | 0.91 | 0.97 | -4.61 | 4.03 |
| | between | 1.04 | -1.87 | 3.23 | |
| | within | 0.36 | -4.61 | 2.86 | |
| Log(Price of capital) | overall | 5.30 | 1.16 | 0.88 | 10.23 |
| | between | 1.17 | 9.67 | |
| | within | 0.43 | 1.1 | 8.69 | |
| Log(Price of labor) | overall | 5.23 | 3.53 | 0 | 29.68 |
| | between | 3.64 | 0.12 | 20.6 | |
| | within | 1.25 | -5.75 | 17.9 | |
| Panel B: Other bank-level variable: | | | | | |
| log(Age) | overall | 3.19 | 0.89 | 0 | 5.18 |
| | between | 0.91 | 0 | 5.17 | |
| | within | 0.19 | 1.49 | 6.19 | |
| log(Total assets) | overall | 13.35 | 1.85 | 5.26 | 18.67 |
| | between | 1.76 | 5.26 | 18.24 | |
| | within | 0.43 | 10.56 | 15.13 | |
| Panel C: Country-level variables: | | | | | |
| log(GDPperCapita) | overall | 7.49 | 0.95 | 5.39 | 9.66 |
| | between | 0.93 | 6.77 | 7.87 | |
| | within | 0.12 | 6.67 | 9.65 | |
| Growth rate | overall | 4.62 | 2.96 | -7.65 | 17.33 |
| | between | 2.59 | -7.65 | 15.11 | |
| | within | 2.18 | -9.63 | 17.21 | |

Notes: Number of bank-year observations is 1,764 for 397 banks. Observation numbers for log(Age), log(GDPperCapita) and Growth rate are 1,745, 1,734 and 1,752 respectively.
Table 3: Descriptive statistics for ownership variables (Within and Between), N=1,764

| Variable                | Panel A: Total costs, profits, inputs and outputs |
|-------------------------|--------------------------------------------------|
|                         | Mean  | Std. Dev. | Min | Max |
| Foreign-owned           |       |           |     |     |
| overall                 | 0.44  | 0.50      | 0   | 1   |
| between                 | 0.50  | 0.11      | 1   |     |
| within                  | 0.02  | 0.11      | 1.11|     |
| State-owned             |       |           |     |     |
| overall                 | 0.08  | 0.27      | 0   | 1   |
| between                 | 0.27  | 0         | 1   |     |
| within                  | 0.02  | -0.06     | 0.94|     |
| Listed                  |       |           |     |     |
| overall                 | 0.26  | 0.44      | 0   | 1   |
| between                 | 0.40  | 0         | 1   |     |
| within                  | 0.06  | -0.6      | 1.13|     |
| Quartile 1 (0-25%)      |       |           |     |     |
| overall                 | 0.08  | 0.27      | 0   | 1   |
| between                 | 0.26  | 0         | 1   |     |
| within                  | 0.07  | -0.67     | 0.97|     |
| Quartile 2 (26-50%)     |       |           |     |     |
| overall                 | 0.15  | 0.36      | 0   | 1   |
| between                 | 0.33  | 0         | 1   |     |
| within                  | 0.09  | -0.74     | 0.9 |     |
| Quartile 3 (51-75%)     |       |           |     |     |
| overall                 | 0.19  | 0.39      | 0   | 1   |
| between                 | 0.37  | 0         | 1   |     |
| within                  | 0.12  | -0.72     | 0.94|     |
| Quartile 4 (76-100%)    |       |           |     |     |
| overall                 | 0.58  | 0.49      | 0   | 1   |
| between                 | 0.48  | 0         | 1   |     |
| within                  | 0.11  | -0.17     | 1.49|     |
| Domestic bank           |       |           |     |     |
| overall                 | 0.44  | 0.50      | 0   | 1   |
| between                 | 0.50  | 0         | 1   |     |
| within                  | 0.03  | -0.47     | 1.11|     |
| Pan-African bank        |       |           |     |     |
| overall                 | 0.25  | 0.43      | 0   | 1   |
| between                 | 0.43  | 0         | 1   |     |
| within                  | 0.02  | -0.42     | 0.58|     |
| Regional bank           |       |           |     |     |
| overall                 | 0.06  | 0.25      | 0   | 1   |
| between                 | 0.25  | 0         | 1   |     |
| within                  | 0     | 0.06      | 0.06|     |
| Middle-East bank        |       |           |     |     |
| overall                 | 0.05  | 0.23      | 0   | 1   |
| between                 | 0.22  | 0         | 1   |     |
| within                  | 0     | 0.05      | 0.05|     |
| Asian bank              |       |           |     |     |
| overall                 | 0.03  | 0.16      | 0   | 1   |
| between                 | 0.15  | 0         | 1   |     |
| within                  | 0.02  | -0.06     | 0.94|     |
| European bank           |       |           |     |     |
| overall                 | 0.15  | 0.36      | 0   | 1   |
| between                 | 0.36  | 0         | 1   |     |
| within                  | 0     | 0.15      | 0.15|     |
| US bank                 |       |           |     |     |
| overall                 | 0.01  | 0.11      | 0   | 1   |
| between                 | 0.11  | 0         | 1   |     |
| within                  | 0     | 0.01      | 0.01|     |

Notes: Descriptive statistics for ownership variables, the number and percentage of banks that are state-owned and that are privately-owned. It shows the number of banks that are foreign-owned and the origins of majority shareholders as well the percentage of shareholding are reported. For quartiles N=1,474 for 324 banks.
| Country                       | 2005 | 2010 | 2015 |
|-------------------------------|------|------|------|
| Algeria                       | 6    | 4    | 2    |
| Angola                        | 9    | 2    | 6    |
| Benin                         | 0    | 10   | 0    |
| Botswana                      | 4    | 6    | 4    |
| Burkina Faso                  | 0    | 8    | 0    |
| Burundi                       | 5    | 1    | 5    |
| Cameroon                      | 1    | 7    | 1    |
| Cape Verde                    | –    | 5    | –    |
| Central African Republic.     | 0    | 1    | 0    |
| Chad                          | 2    | 3    | –    |
| Comoros                       | 0    | 1    | 0    |
| Congo Republic                | 1    | 2    | 1    |
| Côte d’Ivoire                 | 3    | 9    | 1    |
| Democratic Republic of Congo  | 3    | 5    | 3    |
| Djibouti                      | 1    | 2    | 1    |
| Egypt                         | 12   | 12   | 10   |
| Equatorial Guinea             | 0    | 1    | 0    |
| Eritrea                       | 2    | 0    | 0    |
| Ethiopia                      | 10   | 0    | 7    |
| Gabon                         | 3    | 3    | 3    |
| Gambia                        | 0    | 5    | 0    |
| Ghana                         | 10   | 1    | 8    |
| Guinea                        | 0    | 6    | 0    |
| Guinea-Bissau                 | 0    | 0    | 0    |
| Kenya                         | 21   | 12   | 19   |
| Lesotho                       | 1    | 3    | 0    |
| Liberia                       | 0    | 4    | 0    |
| Libya                         | 8    | 0    | 3    |
| Madagascar                    | 1    | 5    | 1    |
| Malawi                        | 2    | 3    | 1    |
| Mali                          | 4    | 6    | 1    |
| Mauritania                    | 3    | 4    | 3    |
| Mauritius                     | 6    | 10   | 6    |
| Morocco                       | 12   | 4    | 12   |
| Mozambique                    | 0    | 9    | 0    |
| Namibia                       | 4    | 6    | 3    |
| Niger                         | 1    | 6    | 1    |
| Nigeria                       | 15   | 4    | 15   |
| Country             | 2005 (1) (2) (3) (4) (5) | 2010 (1) (2) (3) (4) (5) | 2015 (1) (2) (3) (4) (5) |
|---------------------|--------------------------|--------------------------|--------------------------|
| Rwanda              | 4 3 3 1 3 0              | 4 4 3 1 4 0              | 4 4 3 1 4 0              |
| São Tomé and Príncipe| 0 3 0 0 3 0              | 0 3 0 0 3 0              | 0 3 0 0 3 0              |
| Senegal             | 2 9 1 1 8 1              | 2 1 9 1 4 10             | 3 1 9 1                 |
| Seychelles          | 0 4 0 0 4 0              | 0 4 0 0 4 0              | 0 4 0 0 4 0              |
| Sierra Leone        | 4 5 3 1 5 0              | 4 7 3 1 7 0              | 4 7 3 1 7 0              |
| South Africa        | 30 5 27 2 3 30           | 30 5 27 2 3 30           | – 30 5 27 2 3           |
| South Sudan         | 0 2 0 0 1 3              | 0 3 0 1 4 1              | 0 1 4 1 0 1              |
| Sudan               | 5 1 4 1 1 0              | 5 1 4 1 1 0              | 5 1 4 1 1 0              |
| Swaziland           | 1 3 0 1 3 0              | 1 3 0 1 3 0              | 1 3 0 1 3 0              |
| Tanzania            | 11 13 9 2 13             | 13 18 11 17 1 13 19 11   | 2 18 1                 |
| Togo                | 1 5 5 0 1 0              | 1 6 1 6 0 1 0 6 1 6 0 1 0|
| Tunisia             | 9 7 6 3 7 0              | 9 7 6 3 7 0              | 9 7 6 3 7 0              |
| Uganda              | 4 8 4 0 8 0              | 4 13 4 0 13 0            | 5 14 5 0 14 0            |
| Zambia              | 4 8 4 0 8 0              | 5 10 5 0 10 0            | 5 12 5 0 10 0            |
| Zimbabwe            | 4 19 17 1 4 0            | 20 4 18 1 4 0            | – 20 4 18 1 4 0          |

Notes: (1) Domestic, (2) Foreign, (3) Domestic-Private, (4) Domestic-Government, (5) Foreign-Private, (6) Foreign-Government. ‘–’ indicates not available.
Table 5: Main results - Pooled and True Fixed Effects SFA Models for Profit and Cost Efficiency

| Outputs-Inputs: | Pooled models | TFE (Pairwise difference estimator) |
|-----------------|---------------|------------------------------------|
|                 | Profit        | Cost                              | Profit | Profit | Cost   |
| Log(Loans)      | 0.0219        | 0.230***                          | 0.0229 | 0.0395 | 0.312*** |
|                 | (0.72)        | (10.26)                           | (0.53) | (0.91) | (12.97) |
| Log(Total earning assets) | 0.753*** | 0.584***                           | 0.426*** | 0.399*** | 0.473*** |
|                 | (22.81)       | (24.52)                           | (6.78) | (6.29) | (17.19) |
| Log(Price of funds) | -0.0749***  | -0.0302**                          | -0.0694** | -0.0716** | 0.0000923 |
|                 | (-3.24)       | (-2.09)                           | (-2.21) | (-2.35) | (0.01) |
| Log(Price of capital) | -0.0943*** | 0.283***                           | -0.136*** | -0.133*** | 0.122*** |
|                 | (-4.95)       | (23.02)                           | (-4.19) | (-4.14) | (6.95) |
| Log (Price of labor) | -0.00882   | 0.0317***                          | -0.0509*** | -0.0541*** | 0.00466 |
|                 | (-1.33)       | (8.34)                            | (-4.41) | (-4.45) | (1.14) |
| Cons            | 0.784***      | -2.127***                          | –       | –       | –       |
|                 | (3.67)        | (-14.37)                          | –       | –       | –       |

\( \hat{\sigma} = \exp(\gamma y) \)

|  | Profit | Cost | Profit | Profit | Cost   |
|-----------------|--------|------|--------|--------|--------|
| Foreign         | -0.377*** | -0.0992 | -0.0252 | -0.00678 | 0.0734 |
|                 | (-2.71) | (-0.34) | (-0.30) | (-0.08) | (0.84) |
| State-owned     | 0.758*** | 0.860** | 0.321** | 0.344** | -0.163 |
|                 | (3.30) | (2.06) | (2.03) | (2.08) | (-1.12) |
| Listed          | -1.303*** | -0.187 | -0.106 | -0.0749 | -0.0525 |
|                 | (-6.77) | (-0.52) | (-1.25) | (-0.87) | (-0.61) |
| log(Total assets) | –     | –     | -0.0951*** | -0.0832*** | -0.0349* |
|                 | –     | –     | (-3.79) | (-2.99) | (-1.85) |
| log(Age)        | –     | –     | -0.210*** | -0.210*** | -0.0863* |
|                 | –     | –     | (-5.07) | (-4.88) | (-1.77) |
| log(GDP per capita) | –   | –     | –     | -0.101** | -0.131*** |
|                 | –     | –     | –     | (-2.32) | (-2.78) |
| Growth rate     | –     | –     | –     | -0.0252** | -0.0104 |
|                 | –     | –     | –     | (-2.47) | (-1.49) |
| Cons            | 0.636 | -3.750*** | 1.945*** | 2.614*** | 0.226 |
|                 | (1.41) | (-2.89) | (4.86) | (5.62) | (0.54) |
| Year fixed effects | yes | yes | yes | yes | yes |
| \( \psi \)      | 0.660 | 0.569 | 0.0980 | 0.0962 | 0.0219 |
| \( \hat{\sigma} \) | –    | –    | 0.511 | 0.511 | 0.276 |
| \( N \)         | 1,764 | 1,911 | 1,681 | 1,653 | 1,789 |
| No. banks | 397 | 416 | 326 | 321 | 338 |
|-----------|-----|-----|-----|-----|-----|
| Estimated technical inefficiencies, $\hat{u}_t$ |       |     |     |     |     |
| Mean      | 0.727 | 0.186 | 0.467 | 0.462 | 0.314 |
| SD        | 0.647 | 0.141 | 0.541 | 0.539 | 0.264 |
| Min       | 0.115 | -0.832 | 0.004 | 0.004 | 0.001 |
| Max       | 5.13  | 4.49  | 3.85  | 3.95  | 4.12  |

Notes: $t$ statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. $\sigma$ denotes the scale parameter of technical inefficiency $\epsilon_t$ depending on covariates as shown in the table. $\psi$: denotes the standard deviation of the idiosyncratic error component.
Table 6: Shareholders origin - True Fixed Effects SFA Models for Profit Efficiency

|                       | Profit | Profit | Profit |
|-----------------------|--------|--------|--------|
| **Outputs-Inputs:**   |        |        |        |
| Log(Loans)            | 0.0263 | 0.0155 | 0.0314 |
|                       | (0.60) | (0.36) | (0.73) |
| Log(Total earning assets) | 0.430*** | 0.428*** | 0.401*** |
|                       | (7.07) | (6.87) | (6.42) |
| Log(Price of funds)   | -0.0696** | -0.0651** | -0.0677** |
|                       | (-2.19) | (-2.16) | (-2.36) |
| Log(Price of capital) | -0.144*** | -0.132*** | -0.131*** |
|                       | (-4.59) | (-4.10) | (-4.08) |
| Log(Price of labor)   | -0.0539*** | -0.0483*** | -0.0520*** |
|                       | (-5.46) | (-4.15) | (-4.25) |
| $\bar{\sigma} = \exp(\gamma z)$ |        |        |        |
| Domestic banks        | base cat. | base cat. | base cat. |
| Pan African banks     | 0.221** | -0.0221 | -0.0544 |
|                       | (2.35) | (-0.22) | (-0.51) |
| Regional banks        | 0.464*** | 0.226 | 0.138 |
|                       | (2.99) | (1.46) | (0.84) |
| Middle East banks     | 0.0210 | -0.0948 | -0.127 |
|                       | (0.10) | (-0.43) | (-0.56) |
| Asian banks           | -0.00921 | -0.111 | -0.0988 |
|                       | (-0.04) | (-0.42) | (-0.38) |
| European banks        | 0.160 | 0.156 | 0.169 |
|                       | (1.56) | (1.39) | (1.45) |
| US banks              | -0.561* | -0.682* | -0.643* |
|                       | (-1.67) | (-1.90) | (-1.77) |
| State-owned           | 0.345** | 0.345** | 0.366** |
|                       | (2.30) | (2.17) | (2.20) |
| Listed                | -0.302*** | -0.107 | -0.0715 |
|                       | (-3.66) | (-1.26) | (-0.84) |
| log(Total assets)     | – | -0.0927*** | -0.0795*** |
|                       | – | (-3.60) | (-2.74) |
| log(Age)              | – | -0.226*** | -0.229*** |
|                       | – | (-4.99) | (-4.93) |
| log(GDPpercapita)     | – |    –     | -0.111** |
|                       | – |    –     | (-2.31) |
|                           |     |     |         |
|---------------------------|-----|-----|---------|
| **Growth rate**           |     |     | -0.0241** |
|                           |     |     | (-2.32) |
| **Cons**                  | 0.0578 | 1.952*** | 2.703*** |
|                           | (0.20) | (4.48) | (5.13) |
| **Year fixed effects**    | yes | yes | yes |
| **ψ**                     | 0.0802 | 0.103 | 0.101 |
| **σ**                     | 0.501 | 0.510 | 0.510 |
| **N**                     | 1,700 | 1,681 | 1,653 |
| **No. banks**             | 333  | 326  | 321   |

**Estimated technical inefficiencies, \(\hat{\eta}_t\)**

|       |     |     |         |
|-------|-----|-----|---------|
| **Mean** | 0.482 | 0.471 | 0.465 |
| **SD**  | 0.528 | 0.549 | 0.546 |
| **Min** | 0.003 | 0.004 | 0.004 |
| **Max** | 3.75  | 3.85  | 3.97  |

Notes: *t* statistics in parentheses; ‘*p < 0.10’, ‘**p < 0.05’, ‘***p < 0.01’. σ denotes the scale parameter of technical inefficiency \(\eta\) depending on covariates as shown in the table. ψ: denotes the standard deviation of the idiosyncratic error component. Reference category: Domestic banks. Category of US banks omitted because of too few banks.
Table 7: Ownership concentration - True Fixed Effects SFA Models for Profit Efficiency

| Outputs-Inputs:               | Profit  | Profit  | Profit  |
|-------------------------------|---------|---------|---------|
| Log(Loans)                   | -0.00595| -0.00406| 0.00787 |
|                               | (-0.14) | (-0.09) | (0.18)  |
| Log(Total earning assets)    | 0.459***| 0.450***| 0.430***|
|                               | (7.78)  | (7.13)  | (6.62)  |
| Log(Price of funds)          | -0.0570*| -0.0497 | -0.0517*|
|                               | (-1.70) | (-1.58) | (-1.69) |
| Log(Price of capital)        | -0.159***| -0.149***| -0.152***|
|                               | (-5.06) | (-4.43) | (-4.45) |
| Log(Price of labor)          | -0.0682***| -0.0589***| -0.0603***|
|                               | (-6.50) | (-4.26) | (-4.18) |

\( \hat{\sigma} \equiv \exp(\gamma z) \)

| Quartile 1 (1-25%)           | base cat. | base cat. | base cat. |
|-------------------------------|-----------|-----------|-----------|
|                               | 0.397**   | 0.293     | 0.327*    |
|                               | (1.98)    | (1.53)    | (1.69)    |
| Quartile 2 (26-50%)          | 0.136     | 0.0960    | 0.0696    |
|                               | (0.67)    | (0.54)    | (0.40)    |
| Quartile 3 (51-75%)          | 0.155     | 0.0522    | 0.0510    |
|                               | (0.85)    | (0.32)    | (0.32)    |
| Quartile 4 (76-100%)         | Foreign   | -0.218**  | -0.0452   | -0.0323  |
|                               | (-2.46)   | (-0.43)   | (-0.30)   |
|                               | State-owned| 0.322*    | 0.227     | 0.220    |
|                               | (1.82)    | (1.21)    | (1.15)    |
|                               | Listed    | -0.382*** | -0.157    | -0.124   |
|                               | (-4.10)   | (-1.49)   | (-1.19)   |
|                               | log(Total assets) | –    | -0.113*** | -0.103*** |
|                               |           | (-3.65)   | (-3.03)   |
|                               | log(Age)  | –         | -0.205*** | -0.205***|
|                               |           | (-4.30)   | (-4.16)   |
|                               | log(GDP per capita) | –   | –         | -0.0904* |
|                               |           |           |           | (-1.89)  |
|                               | Growth rate| –        | –         | -0.0202* |
|                               |           |           |           | (-1.90)  |
|                               | Cons      | 0.0176    | 2.002***  | 2.612*** |
|                               |           | (0.05)    | (3.74)    | (4.64)   |
| Year fixed effects | yes | yes | yes |
|--------------------|-----|-----|-----|
| $\psi$             | 0.0831 | 0.111 | 0.111 |
| $\bar{\sigma}$    | 0.491 | 0.494 | 0.494 |
| $N$                | 1,424 | 1,408 | 1,389 |
| No. banks          | 274 | 268 | 265 |

Estimated technical inefficiencies, $\hat{u}_i$

|      |      |      |      |
|------|------|------|------|
| Mean | 0.482 | 0.471 | 0.465 |
| SD   | 0.528 | 0.549 | 0.546 |
| Min  | 0.003 | 0.004 | 0.004 |
| Max  | 3.75  | 3.85  | 3.97  |

Notes: $t$ statistics in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.

$\bar{\sigma}$ denotes the scale parameter of technical inefficiency $u_i$, depending on covariates as shown in the table. $\psi$: denotes the standard deviation of the idiosyncratic error component.

Figure 1: Distribution of efficiency scores across African banks, years 2005–2015

Notes: Efficiency scores are predicted from model (4) in Table 5 as $TE = \exp(-\hat{u}_i)$. The mean of cost efficiency is 0.75 and standard deviation is 0.16. The least efficient bank has $TE=0.016$ and the most efficient $TE=0.99$. 