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Original Research

Financial Technology and Profit Efficiency of Commercial Banks in Ethiopia

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Abstract

Ethiopian commercial banks are implementing financial technology (fintech) to help them operate more efficiently and effectively. As a new aspect of financial innovation, fintech has introduced a paradigm shift in financial service delivery in financial institutions, particularly Ethiopian commercial banks. This study aimed to understand how the profit efficiency of commercial banks in Ethiopia responds to financial technology adoption. Unbalanced panel data sets were gathered from 17 sampled banks' financial reports covering 12 reporting years from 2011 to 2022. A stochastic frontier approach was employed. According to the research, Ethiopian commercial banks have a mean efficiency rate of 81.33%, indicating that they are profit-efficient. Moreover, there was a negative relationship between the banks' profit efficiency and the use of fintech. In other words, banking services offered by fintech platforms reduce the profit efficiency of banks working in Ethiopia. The banks are expected to develop a resource management and utilization capability that makes fintech more efficient and transforms the current stage of financial innovation into a correlation effect.

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INTRODUCTION

Profit efficiency measures how efficient a bank is in attaining maximum possible profit relative to the best-practiced bank's profit if the banks utilize the same package of inputs in similar conditions (Reddy & Nirmala, 2013), or "*it tells us how close a bank's actual profits are to what the best-practiced bank's profit is*" (Vu & Turnell, 2010). In this study, a profit-efficient commercial bank generates the maximum profit relative to the best-performing commercial bank's profit from running similar banking business services in the Ethiopian banking industry.

The resource-based view theory suggests that a firm can maintain its competitive advantage and sustainable financial performance by creating unique resources and organizational capabilities that are uncommon, inimitable, and difficult to substitute in the environment the firm operates (Donnellan & Rutledge, 2019; Liang et al., 2010). An empirical study that examines the effect of information technology (IT) on firm performance concluded that technology resources enhance the financial performance of a firm by improving its efficiency and profitability (Liang et al., 2010).

Commercial banks operating in Ethiopia are implementing fintech platforms to help them operate more efficiently and effectively. Financial technology (hereinafter fintech) is a financial service provision platform used to provide transformed banking services to customers using financial innovation tools and online financial services in financial institutions such as banks. As a new component of financial innovation, fintech has caused a paradigm shift in financial service offerings across financial institutions, particularly Ethiopian commercial banks.

It is well documented that the change in banking services delivery because of fintech has improved financial stability (Safiullah & Paramati, 2022), operational efficiency (Li et al., 2021), and decreased commercial banks' willingness to accept risk (Chen et al., 2022; Hu et al., 2022). Fintech advancements encourage commercial banks to be more efficient by lowering the operating costs associated with debtor selection and monitoring and improving customer services and diversifying financial products (Lee et al., 2021; Wang et al., 2024).

However, research findings from China proclaim that a rapid growth in online disbursement deteriorates commercial banks' profit efficiency in the country (Yang et al., 2023). On the other hand, the adoption of fintech has a U-shaped impact on the profit efficiency of commercial banks, and there is no linear relationship between the variables (Wu et al., 2022). Hence, empirical evidence presents mixed findings regarding the association of fintech implementation and the efficiency of banks.

The banking industry dominates Ethiopia's financial system. Banks operating in Ethiopia are mainly owned by the government and domestic private operators; however, the market share of government-owned banks is remarkable. Moreover, over ten years, the banks have witnessed a noteworthy rise in the number of newly founded banks and branch expansion. Recently, the number of newly added private commercial banks has reached 11, representing a 37% growth rate (NBE, n.d.).

Despite fast growth in terms of number and branch expansion, Ethiopian commercial banks' financial reports show depressing financial performance. The mean return on assets of the banks, for example, decreased by 10.50% between 2013–14 and 2021–2022, and the efficiency rate declined by an average of 59% during the period (Ebissa & Lakew, 2025). These adverse financial performances are documented in the period when Ethiopian commercial banks are aggressively using fintech. It indicates the existence of a considerable association between banks' profit efficiency and the adoption of fintech.

Commercial banks licensed to work in Ethiopia are adopting digital financial services since the 592/2008 banking business proclamation and economic reform that was issued to regulate digital banking services in the Ethiopian banking industry. Recently, card, mobile, internet, and agency banking have been widely adopted in commercial banks in the country. Moreover, evidence confirms the presence of more than 136.70 million card banking users and 76.30 million mobile banking subscribers in Ethiopia at the end of 2022 (NBE, n.d.).

Empirical studies examining the profit efficiency of commercial banks from developing nations' perspectives, including Ethiopia, are negligible. There are insufficient empirical studies with scientific insight into profit efficiency and its causes in the Ethiopian banking business, particularly in terms of fintech adoption. Additionally, prior empirical research has focused on cost efficiency rather than commercial banks' profit efficiency (Ebissa & Lakew, 2025; Kiyota, 2011).

On the other hand, research in the economic zones of East Africa (Raphael, 2013) and Sub-Saharan Africa (Kiyota, 2011) is restricted to taking Ethiopian commercial banks into account because of a lack of access to adequate data about the banks (Ebissa & Lakew, 2025). Consequently, there are still significant gaps in the literature from the standpoint of Ethiopian commercial banks, particularly considering empirical research coverage and study methodologies.

Statement of the problem

The research findings provide empirical evidence and policy insights for the banking industry in Ethiopia. Empirically, it determines the present profit efficiency rate of commercial banks operating in Ethiopia and investigates how the adoption of fintech is responding to the banks' profit efficiency. Methodologically, it applies the SFA—a parametric approach, unlike former empirical studies. Finally, it offers policy recommendations for resource management and usage, including the use of financial technology by Ethiopian commercial banks to deliver financial services.

Research questions

In general, the study findings reply to the following research questions.

- What is the current profit efficiency status of commercial banks operating in Ethiopia?
- Does the profit efficiency of Ethiopian commercial banks depend on fintech adoption?

MATERIALS AND METHODS

Sampling and data sources

A report from the National Bank of Ethiopia (NBE) shows the presence of 30 commercial banks licensed to handle the banking business in Ethiopia by the end of 2022 (NBE, n.d.). The following seventeen (17) banks were selected to meet the research objectives: Zemen Bank, Abay Bank, Buna Bank, Berhan Bank, Addis Bank, Abyssinia Bank, Ethiopia Global Bank, CBE, Awash Bank, Wegagen Bank, Hibret Bank, Dashen Bank, NIB Bank, Lion Bank, Oromia Coop Bank, Oromia Bank, and Enat Bank.

Additionally, this study only considered commercial banks that released audited annual reports for at least five sequential financial years between 2011 and 2022. The National Bank of Ethiopia (NBE), the Development Bank of Ethiopia (DBE), and full-fledged interest-free banks were also not considered in the study. These banks were excluded for having banking motives and roles different from those of conventional commercial banks, and the full-fledged interest-free banks have no audited financial reports issued for five consecutive fiscal years. Accordingly, unbalanced panel data were gathered from the annual reports of 17 selected banks that cover 12 reporting years from 2011 to 2022.

Description and measurement of variables

The study's variables were categorized as control factors, input prices, output values, financial technologies, and dependent variables (total profit). Table 1 lists each variable's precise descriptions, measurements, and notations.

Table 1

Variable description and measurement

Description	Variable	Notation	Definition
Dependent variable	Total profit	Π	Total profit before tax (Lu et al., 2018).
Output quantity	Loans	O_1	Total loans and advances (Lu et al., 2018; Reddy & Nirmala, 2013; Srairi, 2009).
	Other earning assets (OEA)	O_2	Investment asset + securities + OEA (Reddy & Nirmala, 2013; Srairi, 2009; Vu & Turnell, 2010).
	Noninterest income	O_3	Commission, exchange, brokerage, etc. (Ebissa & Asfaw, 2025; Reddy & Nirmala, 2013).

***Table 1* continues,**	Price of labor	P_1	Total personnel expenditure/total number of workers (Lu et al., 2018; Vu & Turnell, 2010).
Input prices	Price of funds	P_2	Total interest expenses/total deposits and other interest-bearing liabilities (Lu et al., 2018; Reddy & Nirmala, 2013; Vu & Turnell, 2010).
	Price of physical capital	P_3	Operational cost—personnel cost/total fixed assets (Reddy & Nirmala, 2013; Srairi, 2009; Vu & Turnell, 2010).
Fixed net-put	Equity	E	Equity capital (Vu & Turnell, 2010).
Time period	Time trend	T	Dummy as 1 for 2011 … 12 for 2022.
Control variables	Bank size	B size	Total assets of a bank per annum
	Board size	Bod size	The size of the board of directors in number
	Board composition	B comp	Ratio of females on the board of directors
	Bank ownership	B owner	"Government = 1," "Otherwise = 0."
	Interest rate spread	inter	Loaning interest rate – deposit interest rate
	Inflation rate	infl	$(CPI_t - CPI_{t-1})/CPI_{t-1}$
	Market concentratio	top 2	Ratio of assets of the top two banks to total assets of the sector.
Financial technology	Card banking	Card	Amount of transactions processed per year using ATM & POS terminals.
	Mobile banking	mobile	The number of transactions processed annually using mobile banking.
	Internet banking	internet	The number of transactions processed annually using internet banking.

Model specification

This study examined the profit efficiency of Ethiopian commercial banks using the stochastic frontier approach (SFA). The SFA is a parametric procedure that offers several advantages over nonparametric procedures, such as data envelopment analysis (DEA), for estimating efficiency scores (Srairi, 2009). It separates inefficiency from actual performance and inefficiency due to other stochastic shocks, such as measurement error, bad luck, and/or stochastic shocks (Berger & Humphrey, 1997). It also allows the inclusion of control variables in the efficiency estimation model and provides a comparison basis for efficiency between states or firms (Srairi, 2009).

According to Berger and Humphrey (1997), a parametric process generates a better mean efficiency estimate, implying that it accepts less dispersion in efficiency result estimates than a nonparametric technique. However, the SFA has drawbacks in efficient frontier models for imposing functional form specifications and normal distribution assumptions (Ebissa & Lakew, 2025).

The stochastic function is applied in this study with some specifications. The value of total profit is calculated using the equation to avoid the undefined natural logarithm for negative numbers in case a bank incurs a loss, and represents the absolute value of the lowest amount of earnings of overall banks in the sample. Then, the value is added to the

dependent variable of all banks in the profit function. The profit efficiency score is defined by values between zero and one. A value closer to one indicates more profit efficiency (Ebissa & Asfaw, 2024; Srairi, 2009). Furthermore, an alternative profit efficiency approach was applied to select the three output quantities, such as loans, other earning assets (OEA), and income other than interest income.

The banks' profit efficiency score was then computed via the translog frontier function based on their total operating profit.

$\pi_{it} = f(P_{it}) + \varepsilon_{it}$ ……………………………. (1)

$\varepsilon_{it} = v_{it} - u_{it}$ ……………………………….. (2)

The stochastic π (total profit) function for $bank_i$ Across time, t is defined in terms of the independent variable. P_{it} and the error term(ε_{it}). The error term holds the random error. v_{it} and the inefficiency value u_{it}. v_{it} assumes random error factors that include the results of measurement mistakes, bad luck, and stochastic shocks, and is supposed to follow a symmetric normal distribution around the frontier. Thus, v_{it} is assumed to be independent and identically distributed (iid) with $v_{it}N(0, \sigma_v^2)$ (Ebissa & Asfaw, 2024; Srairi, 2009). The 2nd error term (u_{it}) holds management inefficiency and is assumed to follow a nonnegative truncated distribution above the cost frontier or below the profit frontier (Lu et al., 2018) with mean μ and variance σ_u^2 that fluctuate (Battese & Coelli, 1995; Srairi, 2009). That is, $u_{it}N^+(z_{it\mu}, \sigma_\mu^2)$.

However, the maximum likelihood estimation approach is used to estimate the profit frontier's parameters, which are represented in terms of σ_u^2 & σ_v^2. The way these parameters interact is further described as $\sigma_T^2 = \sigma_u^2 + \sigma_v^2$; $\gamma = \frac{\sigma_u^2}{\sigma_T^2}$. The value of γ ranges from zero to one, with more inefficiency as it approaches one. It is advised to estimate the frontier model using the stochastic frontier method when there is greater inefficiency and OLS when the efficiency score is near zero (Srairi, 2009).

Furthermore, the following equation can be used to predict any bank's profit efficiency (PE) score at time t_i.

$PE_{it} = exp(-u_{it})$ ………………………………… (3)

The translog stochastic profit function presented in equation 4 is employed to predict the coefficients of independent factors for the profit efficiency of the banks. To maintain the linear homogeneity requirements, the output value elements are standardized using the fixed net-put equity capital (E) before taking into account the natural logarithm effects, while the total profit and the input price of labor and funds are normalized using the input price of physical capital (Ebissa & Asfaw, 2024; Srairi, 2009). Standardization (normalization) of predictor variables and output values prevents estimation errors that may occur due to heteroskedasticity and economic scale differences and presents a meaningful interpretation of parameters (Berger & Mester, 1997; Reddy & Nirmala, 2013).

$$\ln\left(\frac{\pi_{it}}{P_3E}\right) = \alpha_0 + \sum_{i=1}^{2}\beta_i \ln\left(\frac{P_i}{P_3}\right) + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2}\beta_{ij}\ln\left(\frac{P_i}{P_3}\right)\ln\left(\frac{P_j}{P_3}\right) + \sum_{s=1}^{3}\gamma_s \ln\left(\frac{O_s}{E}\right) + \frac{1}{2}\sum_{s=1}^{3}\sum_{t=1}^{3}\gamma_{s,t}\ln\left(\frac{O_s}{E}\right)\ln\left(\frac{O_t}{E}\right) + \sum_{i=1}^{2}\sum_{s=1}^{3}\Psi_{is}\ln\left(\frac{P_i}{P_3}\right)\ln\left(\frac{O_s}{E}\right) + \tau_1 T + \tau_2\frac{1}{2}(T)^2 + \sum_{i=1}^{2}\emptyset_i \ln\left(\frac{P_i}{P_3}\right) * T + \sum_{s=1}^{3}\rho_s \ln\left(\frac{O_s}{E}\right) * T + v_{it} - u_{it} \quad \ldots (4)$$

where i, t, and ln designate bank, time, and natural logarithm of the corresponding variable, π, P_i, O_i, E and T designate total profit, input prices, output quantities, equity

capital, and the time trend, respectively. $\alpha, \beta, \gamma, \tau, \Psi, \emptyset, \rho$ denote predictable factors; v_{it} denotes the error term; and u_{it} denotes the inefficiency term.

The drivers of profit efficiency were also investigated using the maximum likelihood estimation technique, based on controlling variables and suggested explanatory variables from financial technology (Table 1). The following regression models were developed based on the work of Baten (2021) to explain the effects of fintech adoption.

$$PE_{it} = \alpha_0 + \alpha_1 lncard_{it} + \alpha_2 lnbsize_{it} + \alpha_3 bodsize_{it} + \alpha_4 bcomp_{it} + \alpha_5 bowner_{it} + \alpha_6 inter_{it} + \alpha_7 top2_{it} + \alpha_8 lninfl_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5a)$$

$$PE_{it} = \alpha_0 + \alpha_1 lnmobile_{it} + \alpha_2 lnbsize_{it} + \alpha_3 bodsize_{it} + \alpha_4 bcomp_{it} + \alpha_5 bowner_{it} + \alpha_6 inter_{it} + \alpha_7 top2_{it} + \alpha_8 lninfl_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5b)$$

$$PE_{it} = \alpha_0 + \alpha_1 lninternet_{it} + \alpha_2 lnbsize_{it} + \alpha_3 bodsize_{it} + \alpha_4 bcomp_{it} + \alpha_5 bowner_{it} + \alpha_6 inter_{it} + \alpha_7 top2_{it} + \alpha_8 lninfl_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5c)$$

where PE_{it} denotes the profit efficiency value, ln is the natural logarithm function, $\alpha_{it}, \beta_{it}, \gamma_{it}$ denotes unknown factors predictable for the corresponding independent variables, and ε_{it} is an error term that has a truncated normal distribution, that is, $\varepsilon_{it} \approx N(0, \sigma_\varepsilon^2)$(Ebissa & Asfaw, 2024).

RESULTS AND DISCUSSION

Results

Descriptive statistics summary

A descriptive statistic related to the study results is summarized in Table 2. Commercial banks in Ethiopia have realized more than 1,393 million ETB in operating profit before tax on average, and there was a commercial bank that reported 14,284 million ETB in losses during the study period. The maximum operating profit before income tax reported by a bank was exceeded by 21,820 million ETB.

The average interest and personnel expenses exceed 1,431 million and 961 million ETB for commercial banks in Ethiopia, respectively. The value of other earning assets (OEA) of the banks was more than 20,977 million ETB in the study period. The average total asset value of commercial banks in Ethiopia between 2011 and 2022 was ETB 52,433.39 million, and there is a bank with a minimum asset value of ETB 380.56 million. On the other hand, the maximum reported asset value was more than one trillion ETB.

The average number of board of directors delegated per bank was around 10 persons, which meets the minimum membership requirement by the National Bank of Ethiopia. The maximum number of board of directors on the commercial bank is seventeen. However, there is a bank governed by a board of directors with only one membership for five consecutive fiscal years, i.e., from 2011 to 2015 in the study period, which is against corporate governance directive number SBB/62/2015 in banks issued by the NBE to guide delegation of board of directors to commercial banks in Ethiopia.

Table 2

Descriptive statistics summary

Variables (million, ETB)	Obs	Mean	Min	Max
Panel A: Input and output variables				
Total profit before tax	198	1,393.90	(14.284)	21,820.61
Other operating expense	194	275.66	-6.77	25,735.66
Interest expense	198	1,431.89	1.10	38,713.92
Personnel expense	198	961.48	3.65	21,263.77
Other administrative expenses	198	604.03	9.78	1,0463.41
Other earning assets (OEA)	198	20,977.64	91.55	722,022.44
Noninterest income	198	1,116.89	7.44	35,816.77
Panel B: Control variables (million, ETB)				
Total assets	198	52,433.39	380.562	1,157,569.50
Number of Board of Directors	198	9.864	1	17
Board Composition (%)	198	15.40	0	57.10
Inflation rate	198	17.149	6.628	33.89
Market concentration	198	69.40	62.30	73.00
Panel C: Financial Technology (millions, ETB)				
Card banking	198	81,221.69	0	259,725.09
Mobile banking	198	139,563.91	0	1,163,572.30

Source: Authors' statistical outputs, 2024

Women's representation on the boards of directors of Ethiopian commercial banks presents additional concerns. Women's participation on the board of directors reached 15% on average, and there is a bank that reserved 57% of the directors' membership for women's involvement, which is the maximum delegation of women on the board of directors in Ethiopian banking history. However, the study result also reveals the presence of a board of directors without a women's delegation to the membership during the study period, which is against the amended banking business proclamation number 592/2008.

Furthermore, two commercial banks own 69% of the total asset values of all banks in the country, and the giant commercial bank owns 73% of the total assets. The remaining total asset values, i.e., 31% on average, were owned by the remaining fifteen commercial banks. This reflects the presence of high market concentration shared between two commercial banks in the Ethiopian banking industry.

Features of Ethiopian commercial banks' profit efficiency

This section's result analysis starts by outlining the characteristics of commercial banks' profit efficiency based on the data shown in Table 3. The effect of financial technology on the profit efficiency of Ethiopian commercial banks is presented in the next section.

Table 3

Summary statistics for profit efficiency scores

	Profit efficiency scores (%)	
Panel A: Commercial banks in rank	Mean	Std.Dev.
Zemen Bank (1st)	96.68	0.000
Awash Bank (2nd)	96.60	0.000
Nib bank (3rd)	92.11	0.000
Commercial Bank of Ethiopia (13th)	73.13	0.000
Overall profit efficiency	81.33	0.092
Panel B: Bank ownership		
Government-owned bank	73.13	0.000
Privately owned banks: Highest	96.68	0.000
Privately owned banks: Lowest	67.46	0.000
Privately owned banks: Average	81.86	0.093
Overall profit efficiency	81.33	0.092
Panel C: Time trend (2011-2022)		
2011	83.24	0.089
2012	82.70	0.088
2013	81.82	0.092
2014 – 2022	80.97	0.096
Overall profit efficiency	81.33	0.092

Source: Author's computation, 2024

The profit efficiency of commercial banks operating in Ethiopia is good on average. The banks realized profit efficiency at 81.33% on average during the study period. In other words, Ethiopian commercial banks are inefficient in profit maximization by only 8.67%, implying the presence of an opportunity for further improvement in profit efficiency by 8.67%.

Privately owned commercial banks realize better profit efficiency than government-owned banks (i.e., Commercial Bank of Ethiopia) in the country. Privately owned commercial banks are ranked from the first to the twelfth most efficient in profit maximization. Even though both the highest (96.68%) and lowest (67.46%) commercial banks in profit efficiency are privately owned banks, the banks' profit efficiency (81.86%) is higher than that of government-owned banks (73.13%) on average.

The profit efficiency of commercial banks in Ethiopia has decreased by 2.27%, from 83.24 % to 80.97%, during the study period. However, the efficiency rate shows a stagnant change for the last nine years of operation, from 2014 to 2022. This was the warmest period in Ethiopian banking history for customizing banking services to financial technology (fintech).

An empirical study conducted in the Chinese banking industry examined the effects of fintech on bank financial efficiency at three stages of fintech development (Wu et al., 2022). Financial efficiency of banks declines in the first stage (competitive effect), gradually increases in the second stage (demonstration effect), and improves significantly in the third stage (correlation effect). However, the study did not provide a full definition and declare a stage for the effect of fintech development when banks realize a stagnant efficiency rate, like commercial banks in Ethiopia during 2014-2022.

Thus, we suggest that commercial banks may experience fintech development effects in four stages. The first stage is a competitive effect where banks realize a declining efficiency rate (Wu et al.,

2022), and the second stage is a survival effect where the banks maintain a stagnant efficiency rate due to fintech adoption. Our study finding reveals that commercial banks in Ethiopia are now at the second stage (survival effect) in adopting fintech. The profit efficacy score of the banks gradually increases and improves significantly at the third stage (demonstration effect) and fourth stage (correction effect), respectively.

According to this viewpoint, the profit efficiency of Ethiopian commercial banks falls into the second stage (survival effect) of fintech adoption, and it is expected to transform into the third stage (demonstration effect) and fourth stage (correction effect) in the future. Once a fintech is deemed a strategic resource, commercial banks in Ethiopia are expected to develop a resource management and utilization capability that makes fintech more efficient and transforms the current stage of fintech adoption effect to a demonstration and correlation effect.

Stochastic regression model: Ethiopian commercial banks' profit efficiency

This study used the translog stochastic frontier model, which permits flexible parameter estimates. Regression analysis of the input price, output quantities, temporal trend, and interaction between these variables is used to estimate the overall operating profit of Ethiopian commercial banks. Table 4 displays the frontier regression results, which are significant and suitable for examination.

Table 4

Time-varying stochastic frontier model

Dependent variable – Total profit $(ln(\pi/P_3\ E))$			Total profit	
Panel A: Input price, Output value, and the cross terms				
Notation	Description	Parameter	Coef.	t value
$ln(P_1/P_3)$	*ln(labor/PPC)*	β_1	-0.002	-0.01
$ln(P_2/P_3)$	*ln(fund/PPC)*	β_2	0.746	4.91***
$1/2ln(P_1/P_3)^2$	$1/2ln(labor/PPC)^2$	β_3	0.044	1.63
$1/2ln(P_2/P_3)^2$	$1/2ln(fund/PPC)^2$	β_4	0.128	5.17***
$ln(O_1/E)$	*ln(loans/Equity)*	γ_1	0.551	4.85***
$ln(O_2/E)$	*ln(OEA/Equity)*	γ_2	-0.166	-2.27**
$ln(O_3/E)$	*ln(noninterest/Equity)*	γ_3	0.191	2.96***
$1/2ln(O_1/E)^2$	$1/2ln(loans/Equity)^2$	γ_4	0.017	0.33
$1/2ln(O_2/E)^2$	$1/2ln(OEA/Equity)^2$	γ_5	0.139	5.17***
$1/2ln(O_3/E)^2$	$1/2ln(non-interest/Equity)^2$	γ_6	0.008	0.51
$ln(P_1/PPC)ln(O_1/E)$	*ln(labor/PPC)* ln(loans/Equity)*	Ψ_1	0.151	2.93***
$ln(P_1/PPC)ln(O_2/E)$	*ln(labor/PPC)* ln(OEA/Equity)*	Ψ_2	-0.003	-0.07
$ln(P_1/PPC)ln(O_3/E)$	*ln(labor/PPC)* ln(noninterest/Equity)*	Ψ_3	-0.038	-1.18
$ln(P_2/PPC)ln(O_1/E)$	*ln(fund/PPC)* ln(loans/Equity)*	Ψ_4	-0.015	-0.30
$ln(P_2/PPC)ln(O_2/E)$	*ln(fund/PPC)* ln(OEA/Equity)*	Ψ_5	-0.027	-0.69
$ln(P_2/PPC)ln(O_3/E)$	*ln(fund/PPC)* ln(noninterest/Equity)*	Ψ_6	0.063	1.93*
T	*Time period*	τ_1	-0.097	-3.96***
$1/2\ (T)$	$1/2\ (Time\ period)$	τ_2	0.009	3.14***
$ln(P_1/PPC)(T)$	*ln(labor/PPC)*(Time period)*	τ_3	-0.016	-1.67*
$ln(P_2/PPC)(T)$	*ln(fund/PPC)*(Time period)*	τ_4	-0.011	-1.49
$ln(O_1/E))(T)$	*ln(loans/Equity)*(Time period)*	τ_5	-0.032	-3.23***

Table 4 continues.

$ln(O_2/E))(T)$	*ln(OEA/Equity)*(Time period)*	τ_6	-0.004	-0.62
$ln(O_3/E))(T)$	*ln(noninterest/Equity)*(Time period)*	τ_7	0.000	0.03
Constant	*Constant*	α_0	1.859	9.86***
Wald Chi-square			2264.33	0.0000
Sigma squared			0.019	1.799
Gamma (γ)			0.915	18.829
Eta (η)			-0.284	-7.520
Log-likelihood function			326.53904	
No. of obs.			198	
No. of group			17	

**** p<1%, ** p<5%, * p<10%*

Source: Authors' frontier regression outcomes, 2024

Initially, at the 1% significance level, the test of zero variation in the model is rejected. This suggests that the coefficients of the parameters are very different from nil and that the explanatory factors greatly describe the current variations in the profit efficiency model. Second, the estimated parameters are significant, as indicated by the sigma-squared value, which is significant at the 10% significance level.

Third, the calculated Gamma value ($\gamma = 0.915,\ 91.5\%$)is similarly highly significant at the 1% significance level, suggesting that while the variance resulting from random error is minimal, a considerable portion of the variation is derived from the inefficiencies of commercial banks. Furthermore, the coefficient of eta (η) (-0.284) deviates significantly from zero, suggesting that the outcomes of the time-invariant and time-varying decay frontier models in this investigation differ significantly. To comprehend the pattern of changes in banks' profit efficiency over time, a time-varying decay frontier model is used.

The stochastic frontier results for the banking sector's profit efficiency in Ethiopia are further examined in this section using the data in Table 4. The stochastic frontier results reveal that the price of labor or personnel expenses does not contribute significantly to the total profit of banks in Ethiopia; however, the effect of the price of funds is highly significant and has a positive association with the total profit of the banks. Additionally, there is compelling evidence that the total profit of Ethiopian commercial banks is positively and quadratically correlated with the input price of funds. It implies that banking services that involve deposit mobilization and borrowing enhance the profit of commercial banks.

For output quantity variables, loans and non-interest income have a significant and positive association with the total profit of the banks; however, the effect of OEA is negative and highly significant at the 1% significance level. Commercial banks boost their total profit through loan generation and non-interest-bearing activities. On the other hand, the total profit of the banks declines due to other earning assets. Commercial banks' engagement in trading investment assets and other securities does not make them profitable.

The stochastic frontier results also reveal that the total profit of commercial banks in Ethiopia shows a declining trend over time. At the 1% significance level, the relationship between the temporal trend and Ethiopian banks' overall profits is substantially negative. This suggests that there has been a noticeable drop in commercial banks' profit efficiency over time. The leading cause of the deterioration in commercial banks' profit efficiency over time is rising labor expenses and loan-generating operations.

The association between labor price loans and total profit is significant and negative across periods. However, the tendency for a gradual increase in the total profit of the banks is revealed across the period. The findings are in line with the empirical findings of Wu et al. (2022) and provide compelling evidence for the existence of a quadratic and positive correlation.

Multicollinearity assumption test

The test for the multicollinearity assumption was conducted using pairwise correlation analysis before running frontier regression models. The pairwise correlation coefficients summarized in Table 5 reveal the presence of a significant multicollinearity problem among fintech platforms. A correlation among card banking, mobile banking, and internet banking was very strong, and the correlation coefficients surpassed 0.94. To resolve the multicollinearity problem, three different frontier regression models were developed, and the prescribed fintech platforms were introduced into each model separately. Three frontier regression models were then used to examine the impact of various fintech platforms on Ethiopian commercial banks' profit efficiency (Table 6).

Table 5

Pairwise correlation analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Profit efficiency	1.000									
(2) Card banking	-0.070	1.000								
(3) Mobile banking	-0.062	0.943*	1.000							
(4) Internet banking	-0.063	0.957*	0.991*	1.000						
(5) Bank size	0.107	0.475	0.548	0.547	1.000					
(6) Inflation	0.028	-0.012	0.236	0.213	0.243	1.000				
(7) Market concentration	0.027	-0.556	-0.757	-0.750	-0.521	-0.696	1.000			
(8) Board of directors size	0.252	0.257	0.288	0.290	0.100	0.103	-0.233	1.000		
(9) Board composition	-0.238	0.194	0.167	0.174	-0.111	-0.044	-0.070	0.135	1.000	
(10) Bank ownership	-0.226	-0.013	-0.012	-0.012	0.566	0.006	0.005	-0.062	-0.011	1.000

** shows significance at p<.05*

Source: Author's computation, 2024

Fintech and Ethiopian commercial banks' profit efficiency

This study aims to examine how Ethiopian commercial banks' profit efficiency is affected by the adoption of fintech. The study uses three proxies of fintech platforms that are in use in the Ethiopian banking sector to examine the role of fintech. The first proxy is card banking. It entails transaction values processed through automated teller machines (ATMs) and point-of-sale (POS) terminals. The second proxy is mobile banking, while the third proxy is internet banking.

The results of frontier regression for financial technology platforms and other control variables are shown in Table 6. The good fitness of all the suggested models is confirmed by the log-likelihood function and the chi-square test. The models explain the current changes in each model with good efficiency at the 1% significance level. The study's results appear to be robust because the variables that are significant in the first model

continue to be significant in the estimation of the second and third models.

Controlling factors are added to each model, and their effects are the same. These variables include bank size (total assets), board of directors size, board composition, bank ownership, interest spread rate, market concentration, and inflation rate.

Table 6

Financial technology and the profitability of commercial banks

Dependent variable: Profit Efficiency		*Model – 1: Card banking*		*Model – 2: Mobile banking*		*Model – 3: Internet banking*	
Explanatory variables	Param.	Coef	t value	Coef	t value	Coef	t value
Card banking	τ_1	-0.004	-2.07**				
Mobile banking	τ_1			-0.006	-2.90***		
Internet banking	τ_1					-0.007	-2.78***
Bank size	τ_2	0.053	9.29***	0.055	9.61***	0.055	9.56***
BoD size	τ_3	0.015	6.60***	0.015	6.81***	0.015	6.79***
Board Composition	τ_4	-0.156	-3.73***	-0.15	-3.65***	-0.149	-3.61***
Bank Ownership	τ_5	-0.349	-10.97***	-0.356	-11.23***	-0.354	-11.19***
Interest rate spread	τ_6	-0.074	-7.31***	-0.074	-7.46***	-0.074	-7.39***
Top2 ratio	τ_7	0.916	2.89***	0.575	1.61	0.574	1.57
Inflation	τ_8	0.005	0.34	0.001	0.10	0	0.02
Constant	τ_0	-0.324	-1.12	-0.084	-0.27	-0.079	-0.25
Number of observations		198		198		198	
Chi-square		190.53***		198.45***		197.18***	
Log likelihood function		257.55		259.55		259.23	

**** p<1%, ** p<5%, * p<10%*

Source: Authors' frontier regression outcomes, 2024

According to the regression results, there is a positive correlation between the profit efficiency of Ethiopian commercial banks and a few control variables, including bank size and board of directors (BoD) size. The effects of bank size and BoD size are highly significant at the 1% significance level. A 1% increase in bank size enhances the profit efficiency by 5.3%, and increasing the number of board of directors by 1 person boosts the profit efficiency by 1.5%. These findings are consistent with earlier empirical results (Bokpin, 2013; Lu et al., 2018).

On the other hand, the effects of board composition, bank ownership, and interest spread rate are negative and highly significant at the 1% significance level in association with the profit efficiency of commercial banks in Ethiopia. A propositional increase in gender diversity in boards of directors decreases the profit efficiency of banks in Ethiopia, and the finding is consistent with previous empirical results (Agoraki et al., 2010). In terms of bank ownership, commercial banks owned by the government are less efficient in profit maximization than privately owned banks. Moreover, the interest spread rate deteriorates the profit efficiency of banks in Ethiopia.

As previously said, our study's primary goal is to examine how fintech contributes to Ethiopian commercial banks' profit efficiency using the resource-based perspective theory and prior

empirical data. Fintech significantly reduces the profit efficiency of Ethiopian commercial banks, as this section demonstrates.

One of the fintech platforms taken into consideration in this study is card banking, which comprises the value of transactions handled via ATM and POS terminals. At a 1% significance level, card banking has a negative and highly significant impact on Ethiopian commercial banks' profit efficiency. To put it another way, commercial banks' profit efficiency drops by 0.04% for every 1% rise in card banking transactions.

Similarly, at a 1% significance level, there is a negative and significant correlation between Ethiopian commercial banks' profit efficiency and mobile banking. This suggests that commercial banks' profit efficiency is not maintained when banking transactions are processed through mobile banking. The profit efficiency of commercial banks decreases by 0.06% for every 1% rise in mobile banking transactions. Stated differently, mobile banking considerably reduces Ethiopian commercial banks' profit efficiency.

Furthermore, the study's findings show that, at the 1% significance level, there is a substantial and negative correlation between online banking transactions and commercial banks' profit efficiency. Consequently, the profit efficiency of the banks decreases by 0.07% for every 1% rise in online banking transactions. The profit efficiency of Ethiopian commercial banks is also negatively impacted by financial transactions completed through online banking.

Both conceptually and theoretically, these results are in line with those of earlier research. Previous empirical studies confirm that financial innovation adversely affects the profit efficiency of banks due to high investment costs, related expenditures mismanagement, and incapability to generate adequate benefits that could respond to costs incurred to run the fintech (Baten, 2021; Gupta et al., 2018; Zhao, 2018). Likewise, a study conducted in the Chinese banking industry confirms the presence of downward movement in the profit efficiency of banks, particularly at the competitive effect (1st stage) of implementing financial innovations (Wu et al., 2022). A similar scenario is observed in the Ethiopian banking industry. As stated in the time trend analysis, the stochastic frontier result reveals a decreasing and stagnant trend in the profit efficiency of commercial banks.

Discussions

The results of our investigation theoretically go counter to the resource-based view theory. This demonstrates that Ethiopian commercial banks are not in a position to create fintech solutions that are unique, hard to replace, and unusual, and that their competitiveness in fintech use is low. To hold their competitive position and improve the contributions of fintech to profit efficiency, commercial banks in Ethiopia shall strive to transform the current fintech adoption stage (survival effect) into the demonstration and correlation effect of fintech adoption. Accordingly, the proposed hypothesis is rejected at a 1% significance level. It implies the absence of a positive association between fintech adoption and the profit efficiency of commercial banks in Ethiopia.

CONCLUSIONS

The profit efficiency of commercial banks in Ethiopia fluctuates between 83.24 % and 80.97%, declining by 2.27% during the study period. Banks operating under private ownership are more efficient than government-owned banks in Ethiopia. The profit efficiency of Ethiopian commercial banks falls into the second stage (survival effect) of fintech, or it has not yet reached the demonstration and correlation effect of fintech adoption.

Banking services that involve deposit mobilization, borrowing funds, and non-interest-income-bearing activities enhance the profit of commercial banks in Ethiopia. However, commercial banks' engagement in trading investment assets and other securities (other earning assets) does not make them profitable, and the profit efficiency of the banks shows a declining and stagnant trend during the study period.

Fintech significantly reduces the profit margins of Ethiopian commercial banks. The supply of financial services through the internet, mobile, and card banking reduces the banks' profit maximization position.

Recommendations

Ethiopian commercial banks are therefore urged to concentrate on efficiently mobilizing more revenue-generating assets and reducing associated expenses. Once a fintech is deemed a strategic resource, the banks are expected to develop resource management and utilization capability that makes fintech more efficient and transforms the current stage of financial innovation into a demonstration and correlation effect.

Our study was focused on investigating the impact of fintech adoption on the profit efficiency of commercial banks in Ethiopia. Fintech adoption is not the only modern issue facing Ethiopian commercial banks, though. Ethiopia's commercial banks are undergoing significant financial advancements, including stock exchange markets, corporate governance, and full-fledged interest-free banking, which could be the subject of future studies. In addition, the cost efficiency of commercial banks is not addressed in this study.

CRediT authorship contribution statement

Tarekegn Tariku: Writing - Original Draft, Writing - Review & Editing, **Deresse Mersha:** Formal analysis, Investigation, Resources, Data Curation, Visualization, **Eshetu Yadecha:** Conceptualization, Methodology, Validation

Declaration of competing interests

The authors affirm that there is no conflict of interest.

Ethical approval

The authors declare that no human participants, their data, or biological material were used in this study.

Data availability statement

Adequate data are available and will be presented upon request.

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