UNIVERSIDADE EDUARDO MONDLANE

FACULTY OF AGRONOMY AND FORESTRY ENGINEERING

Effect of access to Finance on technical efficiency of manufacturing firms in Benin

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In

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DECLARATION

I, Anzim Alabi AGNIDE, hereby declare that this thesis titled " Effect of access to Finance on technical efficiency of manufacturing firms in Benin" is entirely my own work, based on my own research and analysis. All sources used for information and ideas have been duly acknowledged and cited in the text and bibliography. Any assistance received during the course of this research, whether technical, financial, or intellectual, has been acknowledged appropriately.

I affirm that this thesis has not been submitted in whole or in part for any other academic degree or qualification. Furthermore, I understand the principles of academic integrity and have adhered to them throughout the preparation of this thesis.

Anzim Alabi AGNIDE

Date: 30/08/2024

DEDICATION

I dedicate this thesis to my beloved spouse, Faoziyath ABDOULAYE whose unwavering love, patience, and support have been the foundation of my academic pursuits. Your sacrifices and encouragement have provided me with the strength and motivation to overcome challenges and strive for excellence.

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ABSTRACT

This study conducts an empirical investigation of the effects of access to finance on the performance of manufacturing firms in Benin using technical efficiency (TE) as a performance metric. In order to achieve this, we made use of the 2016-year rich enterprise-level data set from the World Bank’s Enterprise Surveys and employ objective measures of access to finance which is measured by the firms access to line of credit or loan from a formal financial institution. From a sample of 70 manufacturing firms, we estimated firms’ technical efficiency employing two stage approach. In the first stage, we employed Stochastic Frontier Analysis (SFA) to estimate technical efficiencies score while in the second stage we examined the effect of access to finance on firm technical efficiency using OLS regression technique. The study highlights three main findings. Firstly, the results from stochastic estimation show that the average TE of the firms is 0.32 (±0.21) with a maximum of 0.74 and a minimum of 0.008, suggesting a significant disparity and gap in efficiency level among Benin manufacturing firms. Secondly, it identifies a positive correlation between access to finance and firm technical efficiency, indicating that credit availability enhances firms' efficiency and growth. This implies that expanding firms need to address credit constraints and secure external financing. Thirdly, older firms tend to have higher technical efficiency compared to mature ones, while smaller firms outperform larger ones. Female ownership is linked to lower efficiency, but firms led by female managers are more efficient. Implementing employee training programs boosts efficiency. Surprisingly, access to finance benefits older firms more than mature ones. However, factors like sector, region, foreign ownership, manager experience, capacity utilization, and regulations don't significantly affect efficiency. To boost the efficiency of manufacturing firms in Benin, policies should prioritize facilitating firm growth through improved capital and credit access, addressing inefficiencies in larger firms, and fostering an inclusive environment that promotes diverse leadership and innovation.

Keywords: Access to finance, Technical Efficiency, manufacturing firms, Stochastic Frontier Analysis, Benin

TABLE OF CONTENTS

LISTE OF TABLES

LISTE OF FIGURES

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CHAPTER ONE: INTRODUCTION

1.1.Background of the study

The private sector plays a crucial role in the economic development of countries worldwide (Allen et al., 2011; Demetriades & James, 2011; Fowowe, 2017; Fowowe & Abidoye, 2013; Gelb et al., 2011; Rahman et al., 2017). In Benin, as in many other emerging economies, private firms are considered the backbone of the economy, contributing significantly to job creation, income generation, and poverty reduction (Di Bella et al., 2013; Ekpo et al., 2014). Benin's economy is characterized by its diversity, with Enterprises spanning various sectors such as agriculture, manufacturing, trade, and services struggling to grow due to lack of financing as noted in most of developing countries (T. H. Beck, 2007; Fowowe, 2017). Access to finance is a fundamental determinant of Enterprises performance, growth and innovation (Ahinful et al., 2023; Fombang & Adjasi, 2018; Fowowe, 2017). Adequate financial resources enable Enterprises to invest in productive activities, expand their operations, create employment opportunities, and innovate (OECD, 2006b). However, private Enterprises in Benin, like in many other developing nations, face numerous challenges in securing the necessary capital for their businesses. These challenges stem from a combination of factors, including limited access to formal banking services, high lending rates, stringent collateral requirements, and often insufficient financial literacy among Enterprises owners (Beck, 2007). The literature extensively documents the significance of finance for the well-being and growth of firms. The term "firm financing gap" has become common, illustrating the prevalent issue of inadequate access to finance, particularly faced by firms (Deakin, 2008; Esho & Verhoef, 2018, 2022). Insufficient finance constitutes a significant obstacle to firm growth and performance (Malhotra, 2007). Research indicates that small firms encounter more significant challenges in obtaining finance compared to their larger counterparts(Beck & Maksimovic, 2002; Schiffer & Weder, 2001).

Moreover, while formal financial institutions, such as commercial banks and microfinance institutions, provide access to credit, they are often constrained by risk aversion, high operational costs making it hard for many firms that are eager to expand to often encounter challenges in obtaining financing from financial institutions, leading to credit constraints (Beck, 2007). This situation gives rise to the financing gap faced by firms, which is more prevalent in developing countries. In contrast, it is not as pronounced in advanced economies due to the adoption of various risk-coping strategies by banks when lending to firms (OECD, 2006b). Therefore, the financing gap is primarily a challenge for developing countries.

It is widely recognized that among developing countries, a subset of African nations faces significant disadvantages in financial development (Allen et al., 2011; T. H. Beck, 2007; Fowowe & Abidoye, 2013, 2013). Consequently, the firm-financing gap is likely to be a more substantial issue for African countries compared to countries in other developing regions (Dinh et al., 2012; Esho & Verhoef, 2018). Indeed, World Bank Enterprise survey data consistently underscores the prominence of access to finance as a major constraint faced by firms (Dinh et al., 2012). In a research encompassing 26 African nations, it became evident that the proportion of firms identifying access to finance as a significant or severe impediment surpassed that of any other constraint, including electricity, corruption, macroeconomic instability, and labor regulations, on average (Gelb et al., 2011). Similarly, in the research conducted by Dinh et al. (2012) analyzing a sample of over 39,000 firms across 98 countries, findings revealed that access to finance emerged as either the primary or secondary obstacle for firms in various regions including Eastern Europe and Central Asia, Sub-Saharan Africa, East Asia and Pacific, Middle East and North Africa, and South Asia. However, in Latin America and the Caribbean, access to finance was identified as the third most significant obstacle. Upon closer examination of the 38 Sub-Saharan African countries in Dinh et al.'s (2012) study, it was observed that electricity ranked as the top constraint in 16 countries, while access to finance held the top position in 11 countries.

This study investigates how access to finance affects firm technical efficiency in Benin, using data from the World Bank's Enterprise Surveys. Our aim is to fill a crucial gap in evidence to inform strategies for improving firm access to finance and driving sustainable growth, essential for poverty alleviation efforts. Through examining the impact of financial access on firms' technical efficiency, we seek to provide valuable insights for policymakers and practitioners.

1.2. Problem statement

The impact of access to finance on firms' performance, particularly their technical efficiency, remains a critical concern in Benin's economic landscape. Despite efforts to improve financial accessibility, there is a lack of comprehensive understanding regarding the extent to which access to finance influences the technical efficiency of firms operating within the country. This study aims to address this gap by investigating the relationship between access to finance and firms' technical efficiency in Benin. By examining the intricate interplay between financial accessibility and firms' operational performance, this research endeavors to provide valuable insights for policymakers, financial institutions, and businesses seeking to enhance economic productivity and growth in Benin.

1.3.Objectives of the study

The general objective of this study is to empirically assess the effect of access to finance on the firm’s technical efficiency in Benin with a specific emphasis on those engaged in food and non-food manufacturing sectors.

The study aims to achieve the following specific goals:

- Assess the technical efficiency of firms using Stochastic Frontier Analysis (SFA)
- Examine the effect of access to finance on firms’ technical efficiency

1.4.Research questions

- What are the technical efficiencies of firms as estimated by Stochastic Frontier Analysis (SFA)?
- To what extent does access to finance influence the technical efficiencies of firms and how do performance levels vary among firms based on different characteristics such as size, age and sector?

1.5.Significance of the study

The significance of the study on the effect of access to finance on firms' technical efficiency in Benin lies in its potential to provide valuable insights into the relationship between financial access and business productivity. Understanding how access to credit influences firms' technical efficiencies can have several implications:

Policy Implications: The findings can inform policymakers about the effectiveness of financial policies and regulations in facilitating access to credit for businesses. This knowledge can guide the development of targeted policies aiming at improving financial inclusion and promoting economic growth.

Business Strategy: For businesses in Benin, the study's results can offer valuable insights into the importance of financial resources in enhancing technical efficiencies. This understanding can guide strategic decision-making regarding investment in technology, human capital, and operational processes to optimize performance.

Economic Development: By elucidating the link between access to finance and firms' technical efficiencies, the study contributes to broader discussions on economic development in Benin. Enhanced technical efficiencies among firms can lead to increased productivity, job creation, and overall economic growth.

Academic Contribution: The study adds to the body of academic literature on the intersection of finance and performance in developing economies. It provides empirical evidence that can enrich theoretical frameworks and serve as a basis for further research in this area.

CHAPTER TWO: LITERATURE REVIEW

2.1. Technical efficiency

The concept of technical efficiency is derived from the production process, which converts input factors (including labor and capital) into products (or production outputs). The overall economic efficiency can be decomposed into two components: (i) technical efficiency and (ii) allocative efficiency.

Technical efficiency can be defined as the capacity and ability of a Firm to generate maximum output from a given bundle of inputs and technology (T. J. Coelli et al., 2005). A firm is considered technically efficient when operating on the efficient production frontier, but inefficiency arises when it falls below this frontier. Additionally, measuring efficiency and identifying sources of firm inefficiency can help discern sources of performance variation, guiding the design of appropriate government policies and recommendations (Fried et al., 2008). The latter concept (allocative efficiency) reflects how efficient firms control their cost. Allocative efficiency represent the firm's ability to equate marginal revenue with marginal cost (Kalirajan & Shand, 1999). While technical efficiency can be measured from the production function, estimation of allocative efficiency requires cost, revenue or profit function.

2.2. Access to finance

Access to finance refers to the availability and ease of obtaining financial services and products, such as credit, loans, savings, insurance, and investment opportunities. It encompasses the ability of individuals, businesses, and other entities to access and use financial resources to meet their financial needs, goals, and obligations (Adamo et al., 2024). Access to finance is essential for economic development and growth, as it enables individuals and businesses to invest in productive activities, expand operations, innovate, and manage financial risks (Amoah et al., 2020; Khan, 2001; Levine, 2005). Without adequate access to finance, individuals may struggle to save for the future, invest in education or housing, or start and grow businesses (Fowowe & Abidoye, 2013; Honohan, 2008). Similarly, businesses may face challenges in accessing the funds needed to invest in new technologies, expand production, or enter new markets. Access to finance can be influenced by various factors, including the availability of financial institutions and services, the regulatory environment, infrastructure, economic conditions, and social and cultural factors (Gamage, 2013; Lago et al., 2007; Rahman et al., 2017, 2017). Efforts to improve access to finance often involve initiatives to expand financial inclusion, promote financial literacy, strengthen financial infrastructure, and enhance regulatory frameworks to ensure that financial services are accessible, affordable, and suitable for all segments of society (Adamo et al., 2024; Khan, 2001).

Financial inclusion refers to the broadening of access to financial services to cover all segments of the population, particularly those who are marginalized or poor (Ozili, 2020). It can also be described as the provision of banking services to underserved and low-income groups at affordable rates (Dev, 2006). Another definition highlights the importance of both utilizing and accessing formal financial services (Sahay et al., 2015). These definitions share a common emphasis on ensuring that every individual has access to available financial services, thereby integrating excluded populations into the formal financial sector and granting them access to formal financial products and services (Allen et al., 2016).

2.3. Relationship between access to finance, firms' characteristics and technical efficiency

Classic elements of production like capital, labor, and materials have a direct impact on technical efficiency. Additionally, other factors, such as access to credit and firm characteristics like age, size, and ownership, play a significant role in influencing technical efficiency.

Theories and empirical studies illustrate the connection between *access to finance* and *technical efficiency*. The principle-agency theory and free cash flow theory suggest that debt positively impacts firm efficiency (Jensen, 1986), arguing that indebted firms have incentives to operate more efficiently. To address the issue of information asymmetry between lenders and borrowers, debtors must be monitored by lenders. Consequently, firms with loans tend to exhibit higher efficiency compared to those without. However, in cases of excessively high agency costs and pressure to meet high interest payments, firms may face liquidity problems. Nickell & Nicolitsas, (1999) discovered that financial pressure can limit employment and capital investment policies which are key determinants of firm efficiency. Another perspective suggests that more efficient firms find it easier to access loans, as lenders prefer to finance less risky firms. According to this concept of credit risk evaluation, technical efficiency can enhance credit accessibility. Numerous empirical studies (e.g., Rios & Shively, (2005), employing DEA method; Binam et al., (2004), employing SFA method) have reported a positive correlation between credit accessibility and technical efficiency. However, some studies, like (Binam et al., 2003), have failed to establish this relationship.

Regarding *firm age*, (Pitt & Lee, 1981) utilized a two-stage regression approach in analyzing the Indonesian weaving industry and determined that firm age, size, and ownership are primary determinants of technical efficiency. This study observed a negative correlation between age and efficiency. Admassie & Matambalya, (2002) investigated small and medium-scale firms in Tanzania's food, textile, and tourism sectors, suggesting a potential positive impact of firm age on technical efficiency according to the theory of learning-by-doing. However, they noted that the effect diminishes over time, particularly for mutual firms. Furthermore, young firms exhibit better ability of applying new technologies. Therefore, firm age can have a negative impact on technical efficiency which is consistent with Admassie & Matambalya (2002) and Binam et al. (2004).

As for firm *size*, Admassie & Matambalya (2002) argued that both too small and too large firms encounter management and supervision challenges. In the context of SMEs, firm size was found to positively affect efficiency, aligning with Pitt & Lee (1981) and Hallberg, (1999). Rios & Shively, (2005) employed a non-parametric method (DEA) to assess technical and cost efficiency among 209 small farming households in Vietnam, corroborating the findings of previous studies by demonstrating a positive relationship between farm size and efficiency. Conversely, Nikaido, (2004) contested this notion, presenting evidence of a negative influence of firm size on technical efficiency using stochastic production frontier model. This result suggests that small firms may benefit from substantial government support, discouraging them from expanding.

2.4. Access to finance and Firm's performance: Other empirical findings

Access to finance positively influences firm performance through various channels. Recent efforts to gather consistent firm-level survey data across countries have enabled researchers to explore these mechanisms and their impact on economic growth and the structure of the economy. Studies utilizing these surveys have revealed that enhancements in the operation of the formal financial sector alleviate financing constraints, particularly for small firms (T. Beck et al., 2005, 2008; T. Beck & Demirguc-Kunt, 2006). Additionally, research indicates that access to finance fosters entrepreneurship, with smaller firms often exhibiting greater dynamism and innovation (Klapper et al., 2006). Improved access to the financial system also enables existing firms to expand and capitalize on growth and investment opportunities, thereby reaching larger equilibrium sizes (T. Beck & Demirguc-Kunt, 2006). Moreover, greater financial inclusion facilitates the adoption of more efficient asset portfolios and encourages innovation (Ayyagari et al., 2007; Claessens & Laeven, 2004). Financial deepening can also incentivize firms to formalize their operations, allowing them to benefit from risk diversification and limited liability (Demirguc-Kunt et al., 2006).

The fundamental principle within that extensive body of literature on the relationship between finance and performance is the idea that finance facilitates performance and growth by allocating credit to the most eligible and suitable firms. A well-developed financial system contributes to economic growth by influencing business expansion, fostering investment, improving household welfare, enhancing allocative efficiency, and facilitating risk diversification (Jun et al., 2007; King & Levine, 1993a, 1993b; Quartey et al., 2017). Macroeconomic evidence consistently suggests that financial development plays a significant role in driving overall economic growth (King & Levine, 1993b; Levine, 2005). Additionally, a growing body of microeconomic research has highlighted the positive influence of finance on the growth trajectories of individual firms (Demirgüç-Kunt & Maksimovic, 1998).

Studies investigating the impact of access to finance on firm performance and growth can be broadly categorized into three groups. The first group consists of early studies that analyzed the relationship between a developed financial sector and firm performance by combining firm-level data with macroeconomic indicators across various countries. Such studies include Demirgüç-Kunt & Maksimovic, (1998), Beck et al., (2006, 2008), Beck & Demirguc-Kunt, (2006); Beck, (2007) and Demirguc-Kunt et al., (2006). The second group comprises country-specific studies that also integrated firm data with measures of financial development, such as Butler & Cornaggia, (2007) and Girma et al., (2008). These studies generally find that well-developed financial systems foster firm performance and growth. The third group focuses on recent firm-level data, particularly from sources like the World Bank, to examine how access to finance and other constraints affect firm performance and growth. Examples include Beck et al., (2005), Ayyagari et al., (2007), Dinh et al., (2012), Aterido & Hallward-Driemeier, (2010), Aterido et al., (2011), Fowowe & Abidoye, (2013) and Fowowe (2017b).

This study is primarily concerned with the third group of studies. Prior research on financing constraints and access to finance has mainly encompassed a wide range of developed and developing countries. However, this study exclusively targets Benin, a west African country which is still less financially developed. By focusing on this country, the study aims to enhance understanding of how improved and more efficient financial markets can contribute to the performance of Benin's firms. The study will use technical efficiency as the metrics of firm performance.

CHAPTER THREE: METHODOLOGY

3.1. Conceptual framework and model specification

Based on theories and empirical studies, a conceptual framework for this study is developed, as illustrated in Figure 1, wherein the relationship between access to credit and technical efficiency will be examined in two stages, as described below.

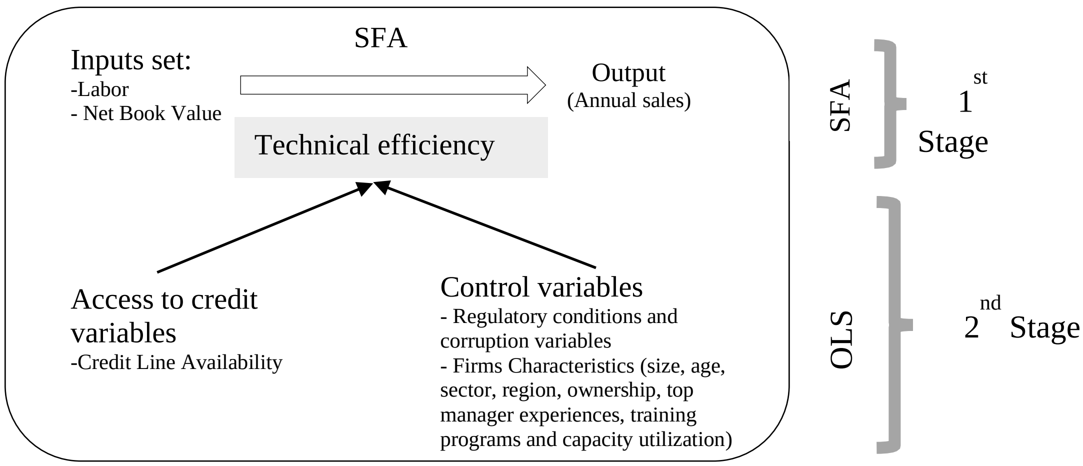

Figure 1: Conceptual framework

3.1.1. First stage: Technical efficiency estimation

3.1.1.1. Technical Efficiency estimation methods

There are many methods for estimating technical efficiency in the existing literature. But the most employed is either the parametric Stochastic Frontier Analysis (SFA), the non-parametric Data Envelopment Analysis (DEA), or a combination of the two in analyzing firms' technical efficiency.

SFA is a parametric approach that estimates a production frontier, representing the maximum output attainable given a set of inputs, and then measures the distance of each firm's observed output from this frontier. It assumes a specific functional form for the production function and accounts for random errors in the estimation process (T. J. Coelli, 1996; T. J. Coelli et al., 2005). One advantage of SFA is its ability to rigorously test hypotheses with statistical methods, while also adhering to known functional forms in the relationship between input and output. SFA facilitates the simultaneous estimation of technical efficiency and technical inefficiency effects (Admassie & Matambalya, 2002; T. J. Coelli et al., 2005). The economic theory of production provides the conceptual foundation for understanding how inputs are transformed into outputs and what constitutes efficient production. SFA is an econometric method designed to estimate production functions and measure technical efficiency within the framework of production theory (Fried et al., 2008).

Conversely, DEA is a non-parametric utilizing linear programming to establish a frontier, free from assumptions about the production function's form and does not require a specific functional form for the production function and can handle multiple inputs and outputs simultaneously (T. Coelli, 1996; Moktar et al., 2023). However, this approach does not distinguish between technical inefficiency and random error (Coelli et al. 2005).

In this study, Stochastic Frontier Analysis (SFA) is chosen for empirical analysis, as it provides reliable and unbiased measurement of technical efficiency levels of firms while accounting for both random errors and inefficiency. In mathematic expression, let's consider a firm utilizing *n* inputs ($x_1, x_2, \ldots, x_n$) to produce a single output *y*. The effective conversion of inputs into output is described by the production function *f*(*x*), which indicates the highest achievable output from different input combinations.

3.1.1.2. Stochastic Frontier Analysis (SFA)

The stochastic frontier production function was initially developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977). Stochastic frontier production function postulates the existence of production technical inefficiency at the firm involved in producing a particular output (T. J. Coelli, 1996). The specification allows a non-negative random component in the error term to generate a measure of technical inefficiency, or the actual ratio to expected maximum output, with the given inputs and the existing technology. Stochastic production frontiers indicate the maximum expected output for a given set of inputs. They are derived from the production theory and are based on the assumption that output is a function of the level of inputs and the efficiency of the producer in using those inputs. The technical efficiency (TE) of an individual firm is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

$$Y_i = f(x_i, \beta) \exp(V_i - U_i) \; ; \; u_i \geq 0 \; ; \; i = 1,2\ldots,n \qquad (1)$$

$$TE = Y_i / Y_i^* \qquad (2)$$

$$TE = [f(x_i, \beta) \exp(V_i - U_i)] / [f(x_i, \beta) \exp(V_i)]$$

$$TE = \exp(-U_i)$$

where *Yi* is the observed output and *Yi** is the frontier output. In the study, "Y" signifies the output value, which is annual sales, measured in monetary units (Francs CFA). The subscript "i" denotes the individual firm, ranging from 1 to 70; "X" stands for the quantity of inputs utilized in production by the ith enterprise, varying between one and "2" inputs. In this study the inputs are the capital (K) and labor (L). K_i represents the capital input of the i-th which is the Net Book Value of the capital in Francs CFA. L_i represents the labor input of the i-th firm which is the number of permanent employees. U_i represents the non-negative random error term of the i-th firm. V_i represents the technical inefficiency effect of the i-th firm which is assumed to follow a half normal distribution

3.1.1.3. Specification of SFA

Before undertaking Stochastic Frontier Analysis (SFA) using Maximum Likelihood Estimators (MLE) approach, for technical efficiency estimation, we conducted OLS-residual-based skewness test, generalized likelihood ratio (LR) test and the use of gamma parameter in order to test on its validity.

First, the OLS-residual-based skewness test allow to verify the existence of one-sided error specification which represents technical inefficiency (U_i) in the model. If evidence for the one-sided error specification is not found, the model then reduces to a standard regression model for which a simple OLS estimation would suffice. The idea behind the test is that, for a production-type stochastic frontier model with the composed error $v_i - u_i$, $u_i \geq 0$ and v_i distributed symmetrically around zero, the residuals from the corresponding OLS estimation should skew to the left (i.e., negative skewness). This is true regardless of the particular distributional function we may choose for u_i in the model estimation after the pretesting. Although useful as a screening device, the test does not use the information from the distribution functions of the random error.

Second, the LR test is more precise to the specific model we are estimating, but the disadvantage is that it can only be conducted after the ML estimation of the model has been undertaken. The generalized likelihood ratio (LR) test for the null hypothesis of no one-sided error can be constructed based on the log-likelihood values of the OLS (restricted) and the SF (unrestricted) model. The LR test statistic is:

$$-2[\mathrm{L}(H_0) - \mathrm{L}(H_1)],$$

where $L(H_0)$ and $L(H_1)$ are log-likelihood values of the restricted model (OLS) and the unrestricted model (SF), respectively, and the degree of freedom equals the number of restrictions in the test.

Third, another often-reported statistics for a similar purpose is the gamma parameter defined as:

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}.$$

Where σ_u^2 is the variance of technical inefficiency component and σ_v^2 is the variance of random error

The γ parameter has a value between 0 and 1, and represents the share of the variance of technical inefficiency relative to the total variance of the composite error. If $\gamma=0$ then there is no inefficiency term in the stochastic frontier model.

In addition to the abovementioned tests for validity, estimation of the frontier function requires one to specify a functional form for the production function along with a distributional form of the inefficiency component of error term. Concerning the functional form for the production function, the Cobb-Douglas (1928) and Translog (Christensen, Jorgenson, and Lau, 1971) production functions are the most commonly used in the literature when estimating technical efficiency. However, for this study, the Cobb-Douglas stochastic frontier production function is more appropriate. The log-likelihood ratio test failed to reject the null hypothesis that the Cobb-Douglas model is nested within the Translog model (LR chi2(3) = 7.68; Prob > chi2 = 0.0532). Using the Cobb–Douglas functional form, a stochastic production frontier model with output-oriented technical inefficiency can be specified as:

$$\ln Y_i = f(x_i, \beta) \exp(V_i - U_i); \quad i = 1,2,...,70 \qquad (3)$$

$$\ln Y_i = \beta_0 + \beta_1 \ln(K_i) + \beta_2 ln(L_i) + (V_i - U_i), \quad i = 1, \ldots, 70 \qquad (4)$$

In the equations (3&4) "ln" represents the natural logarithm and β_0, β_1 *and* β_2 are coefficients to be estimated.

Regarding the distributional forms of the inefficiency component of error term (U_i), the most used in the literature are the half-normal distribution, the truncated-normal distribution, the truncated-normal distribution with scaling properties and the exponential distribution. The half-normal distribution has a single parameter and is thus relatively easy to estimate. For the convenience and data suitability reasons, we preferred in this study the use of half-normal distribution assumption for the inefficiency term (Kumbhakar et al., 2015).

3.1.2. The second stage: OLS Regression Model

In the second stage we first corrected for endogeneity of the variable Creditline by first regressing the endogenous variable (Creditline) on all exogenous variables to obtain the predicted variable of the variable Creditline. Then, we included the predicted variable $\widehat{\mathrm{Creditline}}$ from the regression as the determinant of efficiency in the second stage. The efficiency indices resulted from the first stage is used as the dependent variable in OLS regression (Hoff, 2007; McDonald, 2009) whereas, the independent variables include both access to finance variables ($\widehat{Creditline}$) and control variables. The control variables include *firm size*, *firm age*, *Regulatory conditions and corruption*, *Firm Sector, Region*, *Ownership structure, experiences and gender of the top Manager, employee Training Program and firm Capacity utilization* (*see definition in table1*). In the second stage, we estimate the following model:

$$TE_i = \beta_0 + \beta_1 CREDITLINE_i + \beta_2 MEDIUM_i + \beta_3 LARGE_i + \beta_4 OLD_i + \beta_5 FoodM + \beta_6 Region1 + \beta_7 FOREIGN + \beta_8 FEMOWNER + \beta_9 TM_{Exp} + \beta_{10} TMFEM + \beta_{11} TrainPrg + \beta_{12} CU + \beta_{13} REGULATION_i + \beta_{14} CORRUPTION + \varepsilon_1 \quad (1)$$

The equation shows the effect of *Creditline* variable on firms' technical efficiency (TE) including all the control variables (table1). The variable *CREDITLINE* is an objective dummy variable measuring credit line usage by the firms. Size categories comprise small, medium, and large, but for our analysis, we focus on two categories: medium, and large, with small firms omitted. Regarding the age of the firm, it comprises young, mature and old category. However, because only one firm is considered as young (less than 6 years old) in the data set, thus not representative, the analysis considers only 2 categories (mature & old) with the mature firms omitted. Sector categories include 2 categories including Food manufacturing and non-Food manufacturing which is omitted in the analysis.

We also tested for the Best linear unbiased estimates (BLUE) considering Shapiro wilk test for normality of residual, variance inflation factor (VIF) for multicollinearity testing, and Cameron & Trivedi's decomposition of IM-test for heteroskedasticity testing.

As evident from Eqs. (1), our data lack a time dimension since they are from surveys conducted at a particular point in time. Thus, like other studies, estimations will be carried out using cross-sectional regressions (Dethier et al., 2011).

3.1.3. Variables measurements

Concepts and measurements of these variables are summarized in Table 1 below.

Table 1: Concepts and measurements of variables in the study

Variables	**Variables definition and Measurement**	**Exp sign**
In stage1:		
Input variables		
Wage (L)	Number of permanent employees at the end of fiscal year	+
Capital (K)	Net Book Value of the capital in Francs CFA	+
Output variable		
Sales (Y)	Value of manufactured output sold in a fiscal year in FCFA	
In Stage2:		
Dependent variable		
TE	Technical efficiency index, resulted from stage 1	
Independent variables		
CREDITLINE (Financial access)	Establishment has a line of credit or loans from a financial institution with 1 for having such and 0 otherwise	+
Control variables		
REGULATION1	Percentage of senior management time that was spent in dealing with government regulations ***Comments:*** *As more time is devoted to navigating regulatory requirements, less time and effort are available for activities that directly contribute to technical efficiency. Consequently, this can lead to reduced efficiency in production processes (Aterido et al., 2011b)*	-
REGULATION2	Frequency of inspections or requirements for meeting by tax officials ***Comments:*** *Increased frequency of inspections or meetings may lead to disruptions in the firm's operations, increased compliance costs, and a shift in focus from production activities to dealing with regulatory or bureaucratic requirements. This diversion of resources and attention can hinder a firm's ability to operate efficiently, thereby reducing technical efficiency* (*Djankov et al., 2007)*	-
CORRUPTION	Percent of Total Annual Sales Paid in Informal Payments ***Comments:*** *When a significant portion of a firm's total annual sales is used for informal payments, it diverts resources away from productive investments, such as technology upgrades, employee training, or process improvements. This diversion can reduce the firm's ability to operate efficiently, as resources that could enhance productivity are instead used for non-productive purposes (Fisman & Svensson, 2007).*	-
SIZE	It represents firm size with three categories: Small firms have 5 to 19 employees; Medium firms have 20 to 99 employees; Large firms have over 100 employees. Each category is a dummy variable. Only medium and large categories were considered in the analysis. The small category was omitted. ***Comments:*** *In general, the variable "SIZE" is likely to have a positive impact on technical efficiency, reflecting the benefits of economies of scale and better resource access (Caves et al., 1990)*	+
AGE	It represents firm age with two categories: Mature firms range in age from 6 to 15	+

	years (omitted) and older firms are 16 years and above. The young firms range in age from 1 to 5 years and are not represented in dataset. Only one firm was young and removed from the analysis. Each category is a dummy variable ***Comments:*** *The effect of "AGE" on technical efficiency is context-dependent. In some cases, older firms may demonstrate higher technical efficiency due to experience and established practices, leading to a positive sign. In other cases, the negative impacts of outdated technology or organizational inertia might result in a negative sign. Empirical analysis would help determine the specific relationship between firm age and technical efficiency in a given context* (Huergo & Jaumandreu, 2004). *In the analysis we considered the first hypothesis of positive relationship between firm's age and TE*	
SECTORS	It represents firm sectors with two categories: Food manufacturing (FoodM) and Non-Food manufacturing (NonFoodM). Each category is a dummy variable. But in the analysis, we considered non-food manufacturing as omitted. ***Comments:*** *The impact of the variable "Food manufacturing" on technical efficiency depends on the context in which it is being analyzed. However, typically in empirical studies, this variable could have either a positive or negative sign on technical efficiency depending on various factors such as the specific characteristics of the food manufacturing industry, the technology used, the scale of operations, and the regulatory environment* (Ali & Flinn, 1989).	
REGIONS	It represents firm region with two regions: *Region1:* Dummy variable which has a value of 1 if region is Littoral and 0 otherwise *Region2:* Dummy variable which has a value of 1 if region is Atlantique, Borgou, Mono, Ouémé and 0 otherwise. Region2 was omitted in the analysis. ***Comments:*** *The sign of the "REGION1" variable is expected to be positive in the analysis, because:* • *Firms in Region1 (more urban), industrialized regions might show higher technical efficiency (positive sign) due to better infrastructure and access to resources.* • *Firms in rural or less developed regions (Region2) might exhibit lower technical efficiency (negative sign) due to challenges like poor infrastructure or limited market access* (Chávez & Fonseca, 2012)	+
FOREIGN	It represents firm ownership structure which is Binary variable with a value of 1 if 10% or more of the firm is foreign owned and 0 otherwise. ***Comments:*** *Foreign-owned firms often have access to better technology, management practices, and capital compared to domestically owned firms. They may also benefit from international experience, economies of scale, and global networks, which can enhance their operational efficiency. Thus, firms with 10% or more foreign ownership are expected to be more technically efficient compared to those without significant foreign ownership* (Harrison & McMillan, 2003)	+
FEMOWNER	Binary variable with a value of 1 if there is a female amongst the Owners and 0 otherwise ***Comments:*** *The sign of the "FEMOWNER" variable on technical efficiency depends*	+

	on the specific environment in which the firm operates. In a supportive and equitable environment, the presence of female owners might positively influence technical efficiency (Noland et al., 2016)	
TM_Exp	Years of experiences of the top Manager in years ***Comments:*** *The sign of the variable " TM_Exp " on technical efficiency is generally expected to be positive. The number of years of experience that the top manager has can significantly impact a firm's performance. Experienced managers tend to have a deeper understanding of the industry, better problem-solving skills, and more effective management practices, which can enhance the firm's operational efficiency* (Mincer, 1974).	+
TMFEM	Dummy variable which has a value of 1 if the top Manager is Female and 0 otherwise ***Comments:*** *The impact of the "TMFEM" variable on technical efficiency is context-dependent. In supportive environments with minimal gender bias, the presence of a female top manager might positively influence technical efficiency. However, in contexts where female leaders face significant barriers, the effect might be negative (Duflo, 2012).* *Because of the gender disparities issues in Benin, the expected actual sign in this empirical analysis would be negative***.**	-
TrainPrg	Dummy that takes the value 1 if the enterprise trained its permanent staff in last fiscal years and 0 otherwise ***Comments:*** *Training helps employees perform their tasks more efficiently, reducing errors and waste, which enhances technical efficiency. Given these factors, the "TrainPrg" variable is likely to have a positive impact on technical efficiency (Bartel, 1994).*	+
CU	Capacity utilization (CU) is output produced relative to the maximum amount that could be produced (in %) ***Comments:*** *In empirical studies, capacity utilization is generally expected to have a positive sign on technical efficiency, indicating that higher capacity utilization is associated with higher efficiency. This is because effective use of production capacity typically reflects a firm's ability to maximize output and resource use (Squires & Segerson, 2022)*	+

3.2. Data

The survey was conducted in Benin from July to October 2016 to collect cross sectional data as part of the Enterprise Surveys project, an initiative led by the World Bank. The data was collected in five provinces of Benin divided into two regions. The first region concerns the department of Littoral which is the economic capital city, and the second zone includes Atlantique, Borgou, Mono and Ouémé.

The primary goal of the survey was to gather insights from enterprises regarding the state of the private sector. Additionally, the survey aimed to contribute to the establishment of a panel of enterprise data, enabling the tracking of changes in the business environment over time. This longitudinal perspective facilitates impact assessments of reforms and other transformations. The Enterprise Surveys concentrate on a multitude of factors that influence the business environment, ranging from those that are accommodating to those that act as constraints for firms. These factors play a crucial role in determining whether a country will thrive or face challenges in its economic prosperity (World Bank, 2012). The surveys are systematically administered to a representative sample of firms operating in the non-agricultural formal private economy. Focusing on the manufacturing and services sectors, the survey involved interviews with businesses to evaluate constraints affecting private sector growth.

The core questionnaire answered by business owners and top managers, provide subjective and objective information for a comprehensive understanding of the business environment faced by firms. The subjective assessment shows the severity of obstacles encountered by firms that are asked to rank 16 components of the business environment on a scale of 0–4 (0 denoting no obstacle and 4 indicating a severe obstacle). This approach enables examination of the obstacles considered most important by firms. The objective measures of the business environment, such as the availability of overdraft facilities are valuable in addressing potential shortcomings associated with subjective measures. According to Aterido et al. (2011), drawbacks of subjective measures in assessing the business environment include the observation that firms' perceptions reflect idiosyncratic differences in the levels of optimism or pessimism among the individuals responding to the survey.

The mode of data collection is face-to-face interviews. The sampling methodology for Enterprise Surveys is stratified random sampling. In a simple random sample, all members of the population have the same probability of being selected and no weighting of the observations is necessary. In a stratified random sample, all population units are grouped within homogeneous groups and simple random samples are selected within each group. This method allows computing estimates for each of the strata with a specified level of precision while population estimates can also be estimated by properly weighting individual observations. The sampling weights take care of the varying probabilities of selection across different strata. Under certain conditions, estimates' precision under stratified random sampling will be higher than under simple random sampling (lower standard errors may result from the estimation procedure). The strata for Enterprise Surveys are firm size, business sector, and geographic region within an economy. The survey sample frame is derived from the universe of eligible firms obtained from the economy’s statistical office. For the purpose of this study, we utilize a sample of 70 manufacturing firms for which the data is complete and available for our analysis.

This study aims to investigate the impact of access to finance on the technical efficiency of Benin’s firms. The Creditline availability which is an objective measure of access to finance will be utilized to achieve this research objective. Stata14.2 is used in this study for data management and statistical analysis.

CHAPTER FOUR: EMPIRICAL RESULTS AND DISCUSSION

This section presents the empirical results, including the descriptive statistics of variables of interest, the result of stochastic frontier analysis giving the technical efficiency scores in the first stage and the result of the relationship between these scores and access to finance variables in the second stage.

4.1. Descriptive analysis

The descriptive analysis section includes the descriptive analysis of the control variables on one hand and that of technical efficiency and access to finance on the other hand.

The data reveals that the majority of sampled firms are small (60%), followed by medium (24%) and large (16%) firms, indicating a market dominated by smaller enterprises. Most firms have been operational for at least 16 years (69%), reflecting a mature market with established players, while only 1% of firms are relatively new, suggesting high entry barriers. The non-food manufacturing sector constitutes the primary operational domain for 76% of firms, highlighting a broader industrial focus, with the remaining 24% engaged in food manufacturing. Notably, 21% of firms have significant foreign ownership (more than 10%), indicating international interest and potential global market access, while 31% have female ownership, reflecting a substantial presence of female entrepreneurs. Regulatory conditions impose a significant burden, as senior management spends an average of 12.56% of their time on government regulations, with substantial variation across firms. Firms experience an average of three tax inspections annually, with notable variability, and allocate 2.76% of their total annual sales to informal payments, indicating the presence of corruption in the business environment. Top managers are highly experienced, averaging 24 years of experience, predominantly male (97%), which highlights a significant gender gap in leadership. However, only 20% of firms implemented employee training programs in the previous fiscal year, suggesting limited focus on employee development. Lastly, the average capacity utilization of 70.59% indicates that firms are operating below their maximum potential, with significant room for improvement in efficiency.

The data in the table2 suggests that a majority (approximately 73%) of manufacturing firms did not have a credit line or loan from a financial institution in the year preceding the survey. Only 27% of them had a line of credit. In addition, we observe that 71% of firms with no Creditline have lower efficiency scores below 0.4 against 47% of firms with Creditline that are below the efficiency scores of 0.4. This indicates that having Creditline can increase the efficiency scores of the firms.

In table3, we observe that larger firms have more access to credit than smaller ones as 46% of large firms have access to credit against 35% of medium and only 19% of small firms which have access to credit. However, the level of access to credit is similar between mature and old firms on one hand and alike between food manufacturing and non-food manufacturing on the other hand. This result highlights the limited access to formal credit facilities among manufacturing firms in Benin, which could hinder their ability to invest in growth opportunities, purchase inventory, or finance operational expenses.

Firms' technical efficiency scores are resulted from stochastic frontier analysis using input-oriented approach and half normal distribution of inefficiency term. The distribution of technical efficiencies among the sampled firms presented in Tables4 reveals that technical efficiency scores range from a minimum of 0.008 to a maximum of 0.74, with a mean of 0.32 and a standard deviation of 0.21. This indicates a wide range of technical efficiency among the firms, with significant variation in how effectively they utilize their resources. The average firm is operating at about 32% of its potential efficiency, with some firms being much less efficient and others approaching 74% efficiency.

Analysis by firm size indicates that small, medium, and large firms exhibit varying levels of technical efficiency of 0.29, 0.38 and 0.35 respectively, with small firms displaying the lowest average efficiency. Similarly, older firms tend to demonstrate higher efficiency levels (0.36) compared to younger counterparts (0.23). Non-food manufacturing firms outperform those in the food manufacturing sector with an average technical efficiency level of 0.33 and 0.29 respectively, suggesting disparities in sectoral performance.

Furthermore, firms situated in the Littoral province, which encompasses the economic hub of Benin, exhibit comparable efficiency levels to those in other provinces such as Atlantique, Borgou, and Mono. The average efficiency scores for Littoral and other provinces are 0.32 and 0.33, respectively. On the other hand, firms with less than 10% foreign ownership seem to be less performing than those with more than 10% foreign ownership, with average efficiency scores of 0.31 and 0.36, respectively. In terms of gender composition among owners, firms with female owners demonstrate efficiency levels akin to those without female ownership. The average efficiency scores for firms with and without female owners are 0.30 and 0.33, respectively. The analysis reveals that 34.29% of firms have a TE score below 0.2, 30% have a TE between 0.2 and 0.4, 18.57% have a TE between 0.4 and 0.6, and 17.14% have a TE between 0.6 and 0.8 (Table 5). All of these disparities must undergo statistical verification to establish robust evidence to support them.

Geographical location, ownership structure, and gender composition among owners do not seem to significantly influence technical efficiency levels (table4). However, a notable finding is that a substantial majority of sampled firms (over 80%) operate below the 60% efficiency threshold, signaling substantial room for improvement (table5). Additionally, none of the sampled firms meet the technical efficiency benchmark of 0.82 according to Radam et al., (2008) and Grabowski et al., (1990), indicating a significant efficiency gap. These findings underscore the critical need for policy interventions aimed at enhancing the efficiency of manufacturing firms in Benin.

Table 2: Access to credit and technical efficiency

	Technical efficiency categories				
	0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	
Creditline					Total
NO	21 (87.5)	15 (71.43)	7 (53.85)	8 (66.67)	51 (72.86)
YES	3 (12.5)	6 (28.57)	6 (46.15)	4 (33.33)	19 (27.14)
Total	24 (100)	21 (100)	13 (100)	12 (100)	70 (100)

Key: Frequency without () and column percentage in ()

Table 3: Creditline variable (mean), by firm characteristics

Firms' characteristics	Creditline
Small	0.190
Medium	0.353
Large	0.455
Mature	0.273
Old	0.271
Food Manufacturing	0.235
Non- Food Manufacturing	0.283

Table 4: Technical efficiency scores by firms' characteristics

	Mean	SD	min	max		Mean	SD	min	max
Size					**Regions**				
Small (5-19)	0.294	0.215	0.008	0.741	Zone1(Atlantique…)	0.338	0.228	0.008	0.741
Medium (20-99)	0.383	0.212	0.041	0.683	Zone2 (Littoral)	0.321	0.207	0.019	0.694
Large (100 or more)	0.354	0.190	0.084	0.632	**Foreign owned**				
Age group					Less than 10%	0.315	0.214	0.008	0.741
Mature (6-15)	0.233	0.189	0.035	0.683	10% or more	0.364	0.203	0.070	0.683
Old (16 or more)	0.368	0.209	0.008	0.741	**Female owner**				
Sectors					NO	0.335	0.213	0.008	0.741
Food Manufacturing	0.296	0.171	0.029	0.575	YES	0.305	0.211	0.029	0.632
Non-Food Manufacturing	0.335	0.223	0.008	0.741	**All firms**	0.32	0.21	0.008	0.74

Table 5: Distribution of firms by range of technical efficiency scores

Range of technical efficiency	Freq.	Percent	Cum
0-0.2	24	34.29	34.29
0.2-0.4	21	30	64.29
0.4-0.6	13	18.57	82.86
0.6-0.8	12	17.14	100
Total	70	100	

Table6 provides insight into the challenges encountered by firms in Benin regarding their decision to not apply for new loans or lines of credit in the year preceding the survey. Approximately 34% of the sampled firms, which had adequate capital from owner's equity or existing credit lines, are contrasted with the remaining 66% of firms facing various barriers. Among the primary reasons cited by this majority group are complexities in application procedures (14%), unfavorable interest rates (27%), excessive collateral requirements (14%), insufficient loan size and maturity (2%), lack of confidence in approval (2%), and other reasons (7%).

Overall, the descriptive statistics suggest that access to finance remains a significant challenge for many manufacturing firms in Benin. Addressing these challenges will require concerted efforts from policymakers, financial institutions, and other stakeholders to improve the availability and accessibility of formal financing options, enhance financial literacy among entrepreneurs, and create an enabling environment for business performance, growth and investment.

Table 6: Main Reasons for Not Applying for New Lines of Credit the year preceding the survey year

	Freq.	Percent	Cum.
No need for a loan – establishment had sufficient capital	24	34.29	34.29
Application procedures were complex	10	14.29	48.57
Interest rates were not favorable	19	27.14	75.71
Collateral requirements were too high	10	14.29	90
Size of loan and maturity were insufficient	1	1.43	91.43
Did not think it would be approved	1	1.43	92.86
Other	5	7.14	100
Total	70	100	

4.2. Technical efficiencies estimation: First stage

The objective of this segment of the study was to assess the technical efficiency (TE) levels among manufacturing firms in Benin, with the aim of identifying potential areas for improvement in their operational effectiveness. To estimate technical efficiency, we employed a stochastic frontier analysis (SFA) with a half-normal distribution using Maximum Likelihood Estimates (MLE), and the outcomes are detailed in Table7. The choice of SFA was supported by some pre-test screening such as skewness test on OLS residual (skewness = -0.4622; Pr (skewness) = 0.098) along with generalized likelihood ratio test (Prob<=chibar2 = 0.058; H_o of No inefficiency component was rejected) and the use of gamma parameter obtained after running SFA using MLE method. The value of gamma (γ) also reveals that 86.6% of the variation in output is attributable to technical inefficiency, underscoring the suboptimal utilization of inputs in production activities and operating below the efficiency frontier.

After stochastic frontier model, the result in Table7 illustrates that both capital and labor inputs are significantly associated with annual sales, with a 1% increase in labor and capital resulting in approximately 1.14% and 0.29% increases in output, respectively. Furthermore, the analysis suggests a production technology close to increasing returns to scale, as the sum of coefficients exceeds 1 (1.141+0.295 > 1). The fact that the production technology shows increasing returns to scale implies that, on average, firms could potentially improve their efficiency by scaling up operations and optimizing their input usage. However, the wide range in technical efficiency scores suggests that while some firms are already relatively efficient, many are not fully exploiting the potential benefits of increasing returns to scale.

Table 7: Technical Inefficiency Effects Model for Benin Manufacturing firms

Half Normal Distribution						
lnsales	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lnL	1.141	0.144	7.910	0.000	0.858	1.424
lnK	0.295	0.095	3.110	0.002	0.109	0.480
_cons	11.699	1.622	7.210	0.000	8.519	14.879
/lnsig2v	-0.421	0.829	-0.510	0.612	-2.046	1.204
/lnsig2u	1.444	0.495	2.920	0.004	0.474	2.415
sigma_v	0.810	0.336			0.359	1.826
sigma_u	2.059	0.510			1.267	3.345
sigma2	4.895	1.667			1.627	8.163
lambda	2.541	0.813			0.948	4.135
Number of obs = 70						
Wald chi2(2) = 92.21						
Log likelihood = -124.80872						
Prob > chi2 = 0.0000						
LR text of sigma_u=0 : chibar2 (01)= 2.46				Prob<=chibar2 = 0.058		
(H0: No inefficiency component)						

4.3. Relationship between Technical efficiency and Access to finance: Second stage

The data set used in the study is normally distributed (Shapiro wilk, p = 0.38670). The low correlation scores among variables and low VIF (variance inflation factors) provide evidence that there is no significant correlation among independent variables (result in appendix). These results suggest that the multicollinearity problem is not significant in this study. As for the heteroscedasticity, Cameron & Trivedi's decomposition of IM-test (p= 0.4438) provide evidence that there is no heteroscedasticity in the data. Therefore, the parameters estimated are not biased.

Table 8 displays the outcomes of estimations incorporating the access to finance variable (CREDITLINE) alongside firm controls and business regulatory controls variables. The first column presents results without any controls, the second column includes firm controls, and the third column integrates both firm and business regulatory controls.

The results show that access to credit which is our variable of interest, has a significant positive effect on technical efficiency of Benin manufacturing firms in the three regressions (1-3). This implies that having access to credit lead to a higher performance of manufacturing firms in Benin. In other words, firms who are credit constrained, that is, who do not have access to credit will experience lower performance. These results are similar to other studies who found that access to finance had a positive influence on the performance of African manufacturing firms and firms that are not credit constrained experience faster growth than firms which are credit constrained (Barasa et al., 2018; Bokpin et al., 2018; Brixiová et al., 2020; Buyinza & Bbaale, 2013; Fisman, 2001; Fowowe, 2017; Taddese Bekele & Abebaw Degu, 2023).

Furthermore, we note that certain characteristics of firms are linked to their technical efficiency scores. Specifically, we find a positive correlation between a firm's age and its technical efficiency, whereas size exhibits a negative correlation with technical efficiency. Older firms demonstrate greater efficiency compared to the mature firms, as our analysis excludes young firms due to their limited representation (only one firm is young in the dataset of 70 firms). These results align with previous studies by Söderbom & Teal, (2001), Sleuwaegen & Goedhuys, (2002), and Faruq & Yi, (2010). However, Zhou & Gumbo, (2021) discovered that firm performance tends to decrease with age in developing countries. Regarding firm size, our findings indicate that larger and medium-sized firms are less efficient than smaller ones. This conclusion is consistent with the findings of other researchers such as Bigsten & Gebreeyesus, (2007) and Zhou and Gumbo (2021) in studies conducted in South Africa and Ethiopia, suggesting a negative relationship between firm performance and size.

Additionally, our analysis reveals that firms with female owners tend to exhibit lower efficiency compared to those without female owners. This is inconsistent with (Simo Kengne, 2016) who found that Firms jointly owned by men and women appear to perform better than those owned by men in South Africa. Conversely, firms led by female top managers demonstrate greater efficiency than those led by male counterparts (column 3) as discovered by Makochekanwa & Nchake, (2019) who found that having female manager can increase firm productivity.

Regarding training program variable, firms implementing training programs for employee development tend to operate more efficiently than those that do not. The results align with those of Abugre & Anlesinya, (2020), J. Biggs, (1996), Okumu et al., (2021), (Rismayadi et al., 2019) and (Ritesh Upadhyay, 2023). Abugre & Anlesinya, (2020) found a positive relationship between training participation and employee performance in the manufacturing sector in sub-Saharan Africa, but also noted a positive correlation with employee intention to leave. This suggests that while training can enhance performance, it may also increase worker turnover. Biggs (1996) emphasized the role of private learning mechanisms, such as worker training, in enhancing enterprise productivity. Okumu et al., (2021) further supported this, showing a positive association between training and labor productivity, particularly in older and larger firms. (T. Biggs & Raturi, 1997) highlighted the importance of learning-related technological capabilities in enhancing firm productivity and competitiveness. These studies collectively suggest that employee training programs can improve technical efficiency in the manufacturing sector in African countries, but may also have implications for employee retention and firm competitiveness. However, variables including the sector of operation, geographical region, foreign ownership, top manager experience, capacity utilization, and business regulatory factors show no significant correlation with firm's technical efficiency.

Table 8: Effect of access to finance on technical efficiency of Benin firms

Dependent variable: Technical Efficiency			
Independent variables	1	2	3
Creditline	0.147*** (0.039)	0.356*** (0.029)	0.367*** (0.029)
Old		0.104*** (0.032)	0.101*** (0.036)
Medium		-0.132*** (0.047)	-0.141*** (0.045)
FoodM		-0.017 (0.032)	-0.021 (0.035)
Large		-0.342*** (0.078)	-0.361*** (0.08)
Region1		0.047 (0.03)	0.049 (0.034)
FOREIGN		0.002 (0.05)	0.003 (0.052)
Fem_owner		-0.076** (0.038)	-0.069* (0.041)
TM_Exper		0.00032 (0.0014)	0.0028 (0.0013)
TMFEM		0.092 (0.063)	0.108* (0.061)
TrainPrg		0.079* (0.041)	0.075* (0.042)
CU		0.00013 (0.007)	0.004 (0.0007)
REGULATION1			0.0004 (0.001)
REGULATION2			-0.004 (0.005)
CORRUPTION			-0.002 (0.002)
Constant	0.29 (0.029)	0.45 (0.07)	0.455 (0.062)
R-squared	0.1432	0.7146	0.7228
p-values	0.0000	0.0000	0.0000
Obs.	70	70	70

Column1 includes model without controls; Column2 includes model with firm controls; Column3 includes model with firm and business regulatory controls
Figures without parenthesis are the coefficients and figures in () are the standard errors
*** Indicates significant at the 1% level; ** Indicates significant at the 5% level; * Indicates significant at the 10% level.

4.4. Further analysis by firm size, age and sector

It would be interesting to see how the effects of access to finance on firm technical efficiency are affected by firm characteristics such as age, size and sector. Many studies show differential impact of finance on firm performance based on size and age of the firm. Studies have also found that size is determining factor in firms' access to finance, indicating considerable heterogeneity across firms in access to finance. Aterido et al. (2011) found that smaller firms have less access to finance than larger firms. For African firms, Bigsten & Söderbom, (2006) found that a greater proportion of smaller firms are credit constrained. Similarly, food manufacturing sector has been found to perform better than non-food manufacturing both operating in the same financial market condition (Gołębiewski, 2018; Lunn et al., 2011; Mattas & Shrestha, 1989; Mattas & Tsakiridou, 2010). Thus, we conduct further analysis based on firm size, age and sector and the results are presented in table 9. At first, the results from Tables9 show that access to finance is significantly and positively correlated with technical efficiency. These results offer more support to previous results, and show the importance of finance to firm performance in Benin.

Further analysis, conducted by interacting firm size and age characteristics with access to finance, reveals that older firms with access to finance demonstrate greater efficiency compared to mature firms with similar access. This outcome suggests that access to finance yields more pronounced benefits for older firms and consistent with Söderbom (2001) who found that technical inefficiency is lower in older firms. However, our findings are in contrast with the findings of Fowowe (2017), who observed that credit availability is more advantageous for young firms due to their relative performance compared to older counterparts. Fowowe concluded that young firms stand to gain more from access to finance than older ones.

Additionally, it is seen that small firms perform better and are more efficient than large and medium firms operating in the same condition of access to credit as the interaction variable of access to finance and size have negative coefficients for large and medium size firms (column 1-2). Thus, the availability of credit is more beneficial to smaller firms, as they perform more relative to larger firms. This implies that smaller firms stand to benefit more from access to finance than larger firms. The findings are consistent with Söderbom & Teal, (2004) who found a negative association between firm size and technical efficiency in Ghana, suggesting an inverted U-relationship. Thus, our results support the views of other studies who found that the impact of finance on firm technical efficiency depends on the size of the firm (Aterido et al., 2011; Bigsten and Soderbom, 2006). The unexpected finding that larger and medium-sized firms in Benin are less efficient than smaller firms could be explained by several factors highlighted in the literature, including:

- Complex Management Structures**:** Larger firms often have more complex management hierarchies, which can lead to slower decision-making processes, reduced agility, and less effective communication. These bureaucratic inefficiencies can decrease overall efficiency compared to smaller firms, which typically have more straightforward structures and faster decision-making (Wintrobe & Breton, 1986; Zbirenko & Andersson, 2014).
- Underutilization of Resources**:** Larger firms may struggle with the efficient allocation and utilization of resources. This can occur when firms expand too quickly, leading to overcapacity, underused assets, or difficulties in optimizing production processes. Smaller firms, with more limited resources, might use what they have more efficiently (Penrose, 2009; Williamson, 1985).
- Reduced Flexibility**:** Smaller firms often have the advantage of being nimbler and more innovative, allowing them to quickly adapt to market changes, implement new technologies, and adopt innovative practices. In contrast, larger firms might be more rigid, with established routines that resist change, leading to inefficiencies (Acs & Audretsch, 1988; Croitoru, 2012).
- Innovation Stagnation**:** Larger firms might face innovation stagnation due to their size, where established processes and risk aversion inhibit new ideas and improvements (Teece, 1981, 2018).
- Workforce Challenges: Managing a larger workforce can introduce challenges related to employee coordination, motivation, and productivity. Smaller firms may have closer-knit teams, better communication, and more direct oversight, which can lead to higher efficiency (Brynjolfsson & McAfee, 2014; Greenwood et al., 2017).
- Cost of Compliance: Larger firms might face higher regulatory compliance costs, particularly in environments with complex or inconsistent regulations. These costs can reduce operational efficiency. Smaller firms may benefit from exemptions or less stringent regulatory scrutiny, allowing them to operate more efficiently (Bourguignon & Morrisson, 2002; Djankov et al., 2002).
- Market Saturation and Competition: In a market with intense competition, larger firms might struggle to maintain high efficiency if they face declining market share, pressure to reduce

prices, or difficulty in differentiating their products. Smaller firms might find niche markets where they can operate more efficiently with lower overhead (Krugman, 1991; Porter & Strategy, 1980).

- Access to Technology and Capital: While larger firms generally have better access to advanced technology, in some contexts, smaller firms may adopt new, more efficient technologies more quickly. Additionally, if larger firms are burdened with outdated infrastructure or technology, this could reduce their efficiency (Atkeson & Kehoe, 2007; Henderson & Clark, 1990).
- Also, larger firms might face inefficiencies in capital allocation, especially if they have access to more funding than they can efficiently deploy. Smaller firms, with more limited access to capital, may be more disciplined in how they invest, leading to higher efficiency (Fazzari et al., 1987, 1996; Jensen, 1986)
- Operational Complexity: As firms grow, their operations become more complex, requiring sophisticated management systems and processes. If these systems are not well-implemented or managed, the complexity can lead to inefficiencies that smaller firms do not face (Collis, 2016; Teece, 2018).

Finally, the analysis did not reveal any significant differential effect of access to finance on technical efficiency by sector indicating that access to finance does not have a discernible impact on technical efficiency across different sectors.

Table 9: Effect of access to finance on technical efficiency of firms: further analysis by firm size, age and sector

Dependent variable: Technical Efficiency		
Independent variables	1	2
CREDITLINE	0.224*** (0.028)	0.258*** (0.034)
Creditline X medium	-0.081 (0.075)	-0.105* (0.064)
Creditline X large	-0.28*** (0.055)	-0.316*** (0.071)
Creditline X old	0.166*** (0.026)	0.171*** (0.04)
Creditline X Food Manufacturing	0.0008 (0.078)	0.087 (0.072)
Constant	0.381 (0.028)	0.309 (0.065)
R-squared	0.5916	0.6404
p-values	0.000	0.000
Obs.	70	70

Notes: *Indicates significant at the 10% level; **Indicates significant at the 5% level; ***Indicates significant at the 1% level
Figures without parenthesis are the coefficients and Figures in () are standard errors; Column1 is without controls and column2 include firm and business regulatory controls

CONCLUSION AND POLICY IMPLICATIONS

In summary, our findings yield two key insights regarding the effect of access to finance on firms' technical efficiency in Benin. Firstly, from our analysis we observe significant positive correlation between access to finance and firm technical efficiency suggesting that access to finance through the availability of line of credit enhances firms 'technical efficiency and consequently facilitates firm growth. The findings also suggest that firms aspiring to expand must overcome constraints related to credit and secure additional external financing. Secondly, older firms tend to exhibit higher levels of technical efficiency compared to mature firms, while firm size inversely affects efficiency, with smaller firms outperforming larger counterparts. Additionally, the presence of female owners is associated with lower efficiency, whereas firms led by female top managers demonstrate higher efficiency. Implementing training programs for employee development is linked to increased efficiency as well. Moreover, access to finance appears to benefit older firms more significantly than mature ones, contrary to the conventional belief that credit availability primarily favors younger firms. However, variables such as sector, region, foreign ownership, top manager experience, capacity utilization, and business regulatory factors do not significantly influence technical efficiency. The findings of this study suggest several important policy implications for improving the efficiency of manufacturing firms in Benin.

First, the strong positive relationship between both capital and labor inputs and firm output indicates that policies encouraging firms to scale up operations could enhance productivity. This could include providing incentives for investment in capital and labor, as well as supporting the expansion of firms through access to finance and market development initiatives. Given the evidence of increasing returns to scale in the manufacturing sector, policies that facilitate firm growth, such as infrastructure development and reducing barriers to market entry, could be highly beneficial.

Second, the positive impact of access to credit on technical efficiency highlights the need for policies that improve the availability of affordable credit to firms, particularly smaller and medium-sized enterprises. This could involve strengthening financial institutions, improving credit accessibility through microfinance, and offering government-backed loan guarantees to reduce the risk for lenders.

Third, the finding that larger and medium-sized firms are less efficient than smaller firms points to the need for targeted interventions to enhance the efficiency of larger firms. Policies should focus on streamlining management structures, optimizing resource allocation, and enhancing operational flexibility and innovation. This could involve promoting lean manufacturing practices, offering incentives for R&D, and simplifying regulatory processes to reduce the administrative burden on larger firms. Additionally, workforce management could be improved through training programs on modern HR practices, while access to technology could be facilitated through public-private partnerships and subsidies for technology adoption.

Finally, the varying levels of efficiency among firms, including the influence of firm age and leadership gender, suggest that policies should also focus on fostering an enabling environment for diverse types of firms. For instance, encouraging the participation of women in top management roles, as well as supporting older firms in maintaining their efficiency, could contribute to a more balanced and productive manufacturing sector. Overall, these policy interventions can help address the inefficiencies identified in this study, leading to a more competitive and resilient manufacturing sector in Benin.

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APPENDIX

Appendix A: First stage

A1. Test for stochastic production frontier validity using skewness test of residuals

A1.1. OLS regression

```
. svy:reg lnsales lnK lnL
(running regress on estimation sample)

Survey: Linear regression

Number of strata   =        15              Number of obs     =         70
Number of PSUs     =        70              Population size   =  262.22018
                                            Design df         =         55
                                            F(   2,      54)  =      56.26
                                            Prob > F          =     0.0000
                                            R-squared         =     0.5761

------------------------------------------------------------------------------
             |             Linearized
     lnsales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnK |   .3076695    .100139     3.07   0.003     .1069864    .5083526
         lnL |   1.085977   .1330139     8.16   0.000     .8194109    1.352543
       _cons |    10.1858   1.692168     6.02   0.000     6.794618    13.57698
------------------------------------------------------------------------------
```

A1.2. Prediction and summary of the Residuals

```
.  sum myResiduals2,detail

                          Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -4.585185      -4.585185
 5%    -2.740364      -3.469858
10%    -2.193821       -3.04052       Obs                  70
25%    -1.150343      -2.740364       Sum of Wgt.          70

50%    -.0437315                      Mean           -.202065
                        Largest       Std. Dev.      1.484277
75%     .9744619       1.915699
90%     1.577822       2.124603       Variance       2.203079
95%     1.915699       2.128653       Skewness      -.4622101
99%     2.625261       2.625261       Kurtosis       2.938632
```

A1.3. Skewness test of the residuals

```
.  predict myResiduals2,r

. sktest myResiduals2

                    Skewness/Kurtosis tests for Normality
                                                          ------ joint ------
    Variable |        Obs  Pr(Skewness)  Pr(Kurtosis) adj chi2(2)   Prob>chi2
-------------+---------------------------------------------------------------
myResiduals2 |         70     0.0980        0.8018        2.91         0.2329
```

A2. LR test to choose the right functional forms of the production function

A2.1. Variables computation for translog production function

```
. use "D:\World Bank\Nouvelle version de these\thesis data-stata\data2Anzim 20240516.dta", clear

. gen lnklnl = lnK* lnL

. gen lnksq = (lnK^2)/2

. gen lnlsq = (lnL^2)/2
```

A2.2. Cobb–Douglas estimation

```
. frontier lnsales lnL lnK

Iteration 0:   log likelihood = -125.01196
Iteration 1:   log likelihood = -124.85887
Iteration 2:   log likelihood = -124.80883
Iteration 3:   log likelihood = -124.80872
Iteration 4:   log likelihood = -124.80872

Stoc. frontier normal/half-normal model         Number of obs     =         70
                                                Wald chi2(2)      =      92.21
Log likelihood = -124.80872                     Prob > chi2       =     0.0000

------------------------------------------------------------------------------
     lnsales |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |   1.141198   .1443049     7.91   0.000     .8583661    1.424031
         lnK |   .2945407   .0948314     3.11   0.002     .1086746    .4804067
       _cons |   11.69912   1.622378     7.21   0.000      8.51932    14.87892
-------------+----------------------------------------------------------------
    /lnsig2v |  -.4211838   .8292546    -0.51   0.612    -2.046493    1.204125
    /lnsig2u |   1.444289   .4952732     2.92   0.004     .4735717    2.415007
-------------+----------------------------------------------------------------
     sigma_v |   .8101046   .3358915                      .3594262    1.825881
     sigma_u |   2.058844   .5098451                       1.26717    3.345123
      sigma2 |   4.895108   1.667372                      1.627118    8.163098
      lambda |   2.541455   .8130638                      .9478788     4.13503
------------------------------------------------------------------------------
LR test of sigma_u=0: chibar2(01) = 2.46               Prob >= chibar2 = 0.058

. estimates store cobb_douglas
```

A2.3. Translog estimation

```
. frontier lnsales lnL lnK lnklnl lnksq lnlsq

Iteration 0:   log likelihood = -121.30124
Iteration 1:   log likelihood = -121.11818
Iteration 2:   log likelihood = -121.04106
Iteration 3:   log likelihood = -121.04097
Iteration 4:   log likelihood = -121.00914  (not concave)
Iteration 5:   log likelihood = -120.99949
Iteration 6:   log likelihood =  -120.9926
Iteration 7:   log likelihood = -120.97037
Iteration 8:   log likelihood = -120.97006
Iteration 9:   log likelihood = -120.97004
Iteration 10:  log likelihood = -120.97004

Stoc. frontier normal/half-normal model         Number of obs     =         70
                                                Wald chi2(5)      =     180.73
Log likelihood = -120.97004                     Prob > chi2       =     0.0000

------------------------------------------------------------------------------
     lnsales |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |    .546383   2.535723     0.22   0.829    -4.423542    5.516308
         lnK |   3.916786   2.213407     1.77   0.077    -.4214129    8.254985
      lnklnl |    .017378   .0563732     0.31   0.758    -.0931116    .1278675
       lnksq |  -.2043756    .114407    -1.79   0.074    -.4286092     .019858
       lnlsq |   .0761787   .5684945     0.13   0.893     -1.03805    1.190407
       _cons |  -19.20727   16.29344    -1.18   0.238    -51.14182    12.72728
-------------+----------------------------------------------------------------
    /lnsig2v |  -2.125016   5.259737    -0.40   0.686    -12.43391     8.18388
    /lnsig2u |   1.776564   .7405987     2.40   0.016      .325017     3.22811
-------------+----------------------------------------------------------------
     sigma_v |   .3455881   .9088512                      .0019953     59.8559
     sigma_u |   2.430949   .9001789                      1.176458     5.02314
      sigma2 |   6.028946   3.774681                     -1.369294    13.42719
      lambda |    7.03424   1.792696                      3.520621    10.54786
------------------------------------------------------------------------------
LR test of sigma_u=0: chibar2(01) = 1.65               Prob >= chibar2 = 0.099

. estimates store translog
```

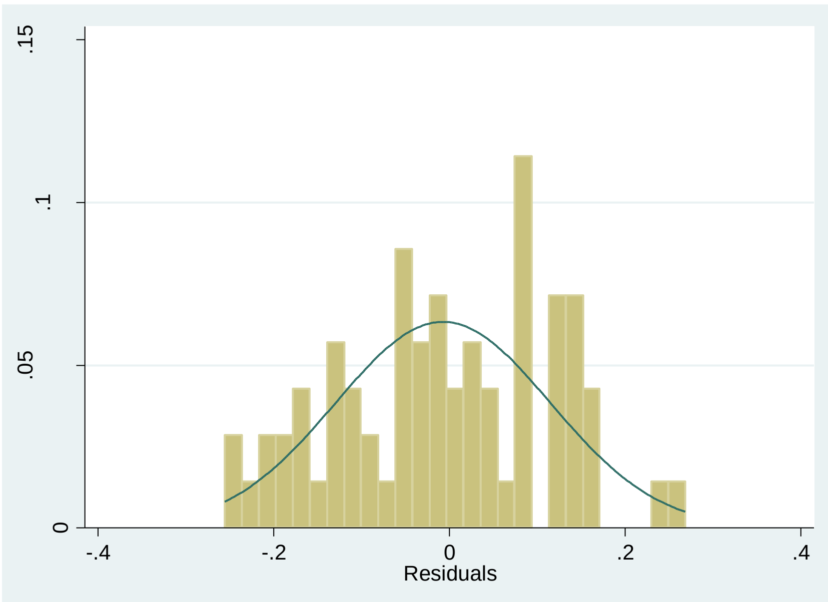
A2.4. LR test to choose between Cobb_ Douglas and Translog production function

```
. lrtest cobb_douglas translog

Likelihood-ratio test                                 LR chi2(3)  =      7.68
(Assumption: cobb_douglas nested in translog)         Prob > chi2 =    0.0532
```

Appendix B: Test for Best linear unbiased estimator (BLUE) : Second stage

B1. Distribution of the residuals



B2. Result of Shapiro wilk test

```
. predict residual, resid

. swilk residual

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
    residual |         70    0.98145      1.142     0.288    0.38670

. hist r, fraction bin(27) normal
(bin=27, start=-.25570631, width=.01942655)
```

B3. Correlation matrix among the variables

```
. corr TE Creditlin Medium Large Old FoodM Region1 FOREIGN Fem_owner TM_Exper TMFEM TrainPrg CU REGULATION1 REGULATION2 CORRUPTION
(obs=70)
```

	TE	Credit~n	Medium	Large	Old	FoodM	Region1	FOREIGN	Fem_ow~r	TM_Exper	TMFEM	TrainPrg	CU
TE	1.0000												
Creditlin	0.6272	1.0000											
Medium	0.1562	0.2357	1.0000										
Large	0.0595	0.5876	-0.2445	1.0000									
Old	0.2992	0.0825	-0.0472	-0.0459	1.0000								
FoodM	-0.0791	0.1087	0.0677	0.1216	-0.1907	1.0000							
Region1	0.0358	-0.1397	-0.1045	-0.0744	-0.0945	0.0479	1.0000						
FOREIGN	0.0952	0.3715	0.0290	0.4442	-0.1714	0.1914	0.0910	1.0000					
Fem_owner	-0.0656	0.0591	0.0472	0.0459	0.1269	0.0472	-0.1871	-0.0536	1.0000				
TM_Exper	0.0807	0.0247	0.1066	-0.0628	0.2440	-0.1112	-0.3309	-0.0541	0.0075	1.0000			
TMFEM	-0.1256	-0.2504	-0.0277	-0.1198	-0.0512	0.1016	-0.0363	-0.1448	0.2902	-0.2832	1.0000		
TrainPrg	0.0149	0.2359	0.0500	0.1766	0.0308	0.3831	0.0327	0.0870	-0.0308	0.1376	-0.1387	1.0000	
CU	0.1536	0.1850	-0.1084	0.1361	-0.0534	-0.0598	0.0211	-0.0034	-0.0503	0.0268	-0.0406	0.0390	1.0000
REGULATION1	0.0030	0.0936	-0.1988	0.1011	-0.1360	-0.1484	-0.1863	-0.1770	0.1900	-0.0155	0.0654	0.0769	0.2102
REGULATION2	0.1594	0.1495	-0.0834	-0.0045	0.1127	0.0309	0.0818	-0.0667	-0.0455	-0.0726	-0.0643	0.0646	0.2849
CORRUPTION	-0.0451	-0.0397	-0.0857	-0.1034	-0.1104	-0.1129	-0.1809	-0.0871	0.1817	-0.2480	0.1981	-0.0710	0.0925

	REGULA~1	REGULA~2	CORRUP~N
REGULATION1	1.0000		
REGULATION2	0.0545	1.0000	
CORRUPTION	0.4351	-0.1068	1.0000

B4. Result for variance inflation factor (VIF)

```
. vif
```

Variable	VIF	1/VIF
Creditlin	2.89	0.346069
Large	2.68	0.373316
Medium	1.72	0.581477
REGULATION1	1.70	0.587672
Old	1.64	0.609865
FOREIGN	1.64	0.610512
FoodM	1.54	0.649157
TM_Exper	1.43	0.700834
Region1	1.42	0.704581
CORRUPTION	1.41	0.707393
TrainPrg	1.37	0.730065
Fem_owner	1.37	0.730150
TMFEM	1.35	0.741525
REGULATION2	1.31	0.762928
CU	1.25	0.800904
Mean VIF	1.65	

B5. Residual square regression model

Source	SS	df	MS			
				Number of obs	=	70
				F(15, 54)	=	0.52
Model	.00250283	15	.000166855	Prob > F	=	0.9198
Residual	.017407038	54	.000322353	R-squared	=	0.1257
				Adj R-squared	=	-0.1172
Total	.019909868	69	.000288549	Root MSE	=	.01795

residual2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Creditlin	.0016905	.0052624	0.32	0.749	-.00886	.012241
Medium	.0034313	.0064503	0.53	0.597	-.0095007	.0163634
Large	.0124559	.0093174	1.34	0.187	-.0062244	.0311362
Old	-.0044735	.0053581	-0.83	0.407	-.0152159	.0062688
FoodM	-.0029892	.005962	-0.50	0.618	-.0149424	.0089639
Region1	.0048793	.0057713	0.85	0.402	-.0066915	.0164502
FOREIGN	-.0082409	.0064245	-1.28	0.205	-.0211213	.0046396
Fem_owner	.0052853	.0051474	1.03	0.309	-.0050346	.0156053
TM_Exper	4.95e-06	.0002332	0.02	0.983	-.0004625	.0004724
TMFEM	-.0010031	.0097701	-0.10	0.919	-.0205909	.0185847
TrainPrg	.0040985	.0062772	0.65	0.517	-.0084866	.0166836
CU	-.0001008	.0000967	-1.04	0.302	-.0002947	.000093
REGULATION1	-.0000749	.0001332	-0.56	0.576	-.0003419	.0001922
REGULATION2	.0004982	.0007462	0.67	0.507	-.0009978	.0019942
CORRUPTION	.0002666	.0003679	0.72	0.472	-.0004709	.0010041
_cons	.0200906	.0115679	1.74	0.088	-.0031017	.0432829

B6. heteroscedasticity test result

```
. imtest

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	70.00	69	0.4438
Skewness	29.03	15	0.0160
Kurtosis	1.97	1	0.1604
Total	101.00	85	0.1136