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Assessing Productivity and Efficiency in the Mozambican Banking Sector

Gabriel Hilário Lemequezani

Dissertation presented as the partial requirement for obtaining a Master's degree in Statistics and Information Management

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Advisor: Professor Doutor Jorge Miguel Ventura Bravo

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DEDICATION

To my parents, my wife, my children, and my friends and colleagues who always made me to believe.

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ABSTRACT

With the new trends on the Information Systems (IS) and consequently, the new approaches on Enterprise Resource Planning (ERP) and Business Intelligence (BI), the world became a small place, where the knowledge can flow spirally, allowing the champions to introduce new business processes to advance firm's performance (Robles-Flores, Kulkarni & Popovič, 2017). The present research, tries to assess the productivity of the Mozambican banking sector, considering their traditional core business of transformation of deposits into credits efficiently, and then to find which variables contribute for it.

For that, the directional distance function (DDF), and the metafrontier-Luenberger productivity indicator (Kevork, Pange, Tzeremes & Tzeremes, 2017; Zhu, Wang & Wu, 2015), were used, through Data Envelopment Analysis (DEA), to assess the efficiency and the total factor productivity (Maudos, Pastor & Serrano, 1999). The OLS model was used to evaluate the determinants of the Total Factor Productivity Change (TFPCh), in the 16 Mozambican commercial banks over the period between 2008 and 2018.

Considering the intermediation approach and index numbers, the results revealed that Mozambican banks do not operate efficiently in terms of loans allocation. For instance, in this period, the TFPCh observed an average negative growth of 1.02%, suggesting that the Mozambican banking sector does not survive from intermediation business process. The OLS model confirmed that eight out of the eleven elected explanatory variables, had significant influence on the performance of the banking system.

KEYWORDS

Data Envelopment Analysis (DEA); Efficiency; Malmquist Productivity Index (MPI); Total Factor Productivity (TFP); Mozambican Banking Sector.

RESUMO

Com as novas tendências nos Sistemas de Informação (SI) e, consequentemente, as novas abordagens no *Enterprise Resource Planning* (ERP) e *Business Intelligence* (BI), o mundo se tornou um lugar pequeno, onde o conhecimento pode fluir em espiral, permitindo as instituições a introdução de novos processos de negócios para melhorar o desempenho da empresa (Robles-Flores, Kulkarni & Popovič, 2017). A presente pesquisa tenta avaliar a produtividade do setor bancário moçambicano, considerando seu principal negócio tradicional de transformação de depósitos em créditos de forma eficiente, e depois descobrir quais variáveis contribuem para isso.

Para isso, foram utilizadas a função distância direcional (DDF) e o indicador de produtividade *meta-fronteira-Luenberger* (Kevork, Pange, Tzeremes & Tzeremes, 2017; Zhu, Wang & Wu, 2015), por meio da Data Envelopment Analysis (DEA), para avaliar a eficiência e a produtividade total dos fatores (Maudos, Pastor & Serrano, 1999). O modelo OLS foi utilizado para avaliar os determinantes da Produtividade Total dos Fatores (TFPCh), nos 16 bancos comerciais de Moçambique no período entre 2008 e 2018.

Considerando a abordagem de intermediação e os números de índices, os resultados revelaram que os bancos moçambicanos não operam eficientemente em termos de alocação de empréstimos. Por exemplo, neste período, a productividade (*TFPCh*), observou um crescimento negativo médio de 1,02%, sugerindo que o setor bancário moçambicano não sobrevive do processo comercial de intermediação. O modelo OLS confirmou que oito das onze variáveis explicativas eleitas tiveram influência significativa no desempenho do sistema bancário.

PALAVRAS-CHAVE

Análise Envoltória de Dados (*DEA*); Eficiência; Índice de Produtividade Malmquist (*MPI*); Produtividade Total dos Fatores (*TFP*); Sector Bancário de Moçambique.

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LIST OF ABBREVIATIONS AND ACRONYMS

AMB	Associação Moçambicana de Bancos (Mozambican Banking Association)
BM	Banco de Moçambique (Bank of Mozambique)
BdP	Banco de Portugal
CAR	Capital Adequacy Ratio
CCT	Comissão Consultiva de Trabalho
DEA	Data Envelopment Analysis
DDF	Directional Distance Function
ECB	European Central Bank
ERP	Enterprise Resource Planning
ESA	European System of Accounts
ESS	European Statistical System
GDP	Gross Domestic Product
GG	General Government
HH	Household
HHI	Herfindahl-Hirschman Index
ICT	Information and Communications Technologies
IMF	International Monetary Fund
INE	Instituto Nacional de Estatística (National Institute of Statistics)
IT	Information Technologies
MFP	Multifactor Productivity
NFC	Non-Financial Corporation
NPL	Non-Performing Loan
NSS	National Statistical System
OECD	Organization for Economic Co-operation and Development
RAS	Risk Assessment System
ROA	Return On Assets

ROE	Return On Equity
SEN	Sistema Estatístico Nacional
SSA	Sub-Saharan Africa
TFP	Total Factor Productivity

1. INTRODUCTION

Banks represent a subsector of the financial industry whose main purpose is financial intermediation (Vithessonthi, 2016), that is, they collect money from savers (liabilities) and provide it to borrowers (assets), through lending (Manaba, Thengb & Md-Rusc, 2015). By doing this, they look to meet customer's needs, increase their profits and serve as catalytic in the economic growth (Vithessonthi, 2016).

The soundness of a banking sector (Dimitrios, Helen & Mike 2016; Tsumake 2014), is directly affected by various variables (internals and externals), with effect to the economic growth and welfare of a stable and efficient banking system (Fernandes, Stasinakis & Bardarova, 2018), mainly for emerging economies (Gunes & Yildirim, 2016). That is why banks look to maintain their asset quality, efficiency and profitability, the vital requirements for the survival and development (Zimkova, 2014). Therefore, efficient use of the labour, better use of time, lowering the cost, the economy of scale, among others, can help to achieve those goals.

The assessment of the performance of banks on regular basis is of crucial importance to ensure the financial stability (Adhikari, 2017). Coelho & Vilares (2010) state that the production of measures of profitability can facilitate the comparability of the firm's performance, hence, accounting recording and reporting help managers to achieve their objectives regarding internal and external reporting for accountability purposes (Jesus & Eirado, 2011).

Many studies from variety of fields, using different techniques, have been developed (Mousavi, Ouenniche & Tone, 2019), to assess firm's performance. However, the two most prevalent frontier methodologies (Chen, Delmas & Lieberman, 2015), used to compute the TFP index are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). In the context of DEA, one of the approaches applied for productivity measurement is the Malmquist Productivity Index (MPI) (Chen & Young, 2011; Wang & Lan, 2011).

For instance, the present study applies MPI to measure the total factor productivity. The aim is to assess the performance of the banking industry. Later, the determinants of it are evaluated, from the banking key variables (monetary and ratios), to the macroeconomic indicators (Kar & Rahman, 2018), namely, non-performing loans, level of capitalization, liquidity risk, ROA, ROE, GDP, interest rates, etc.

Two factors inspired this study: (i) the use of DEA, because it appears to be the most used technique in many researches about productivity and efficiency in the banking sector and, (ii) the need of reduction of the literature gap in the country concerning the subject.

For this dissertation consists of six chapters structured as follows: The first chapter is entitled "introduction". The chapter addresses the specific issue of "Study relevance", and "Study objectives". The second chapter entitled "Literature review" is related to assessing productivity and efficiency in the Banking Sector, its theory and practice. The third chapter is about the "Methodology used", presenting the whole investigative strategy, starting with the justification of the methodological option, this is, by describing the path we used to reach the desired results, the type of research, the chosen paradigm, the method, data collection, processing and analysis techniques, as well as participants. The fourth chapter, entitled "Result and Discussion" refers to everything we collect in the field of study, including analysis and discussion of data. The fifth chapter formulated as: "Conclusions" presents the results of the research seeking to highlight what we have achieved and whether the most relevant conclusions from a perspective of valuing new knowledge that may be useful to the Mozambican reality. The chapter also concerns the limitations of the study and recommendations for the future researches. Finally, the Bibliographic References.

1.1. BACKGROUND

Banking systems in Sub-Saharan Africa (SSA) have grown considerably in recent years due to various factors, such as favourable macroeconomic environment, regulatory and financial trends, etc. But the risks remain elevated due to structural issues, commodity price fluctuations, reversal of capital flows and spillover effects from external shocks (Adesina, 2019; Nikolaidou & Vogiazas, 2017). Credit risk management and banking objectives (Nikolaidoua & Vogiazas, 2017) are important issues that must be carefully handled by the bankers (Bravo & Silva, 2006; Chamboko & Bravo, 2016, 2019a,b), especially private commercial banks, for the successful operation of their business performance (Moro, Cortez & Rita, 2014).

The regulator has his role in this process, to prevent the occurrence of banking problems (Abid, Ouertani & Zouari-Ghorbel, 2014), thus, understanding the mechanisms at play behind NPLs, in any situation of the economy, is crucial (Nikolaidou & Vogiazas, 2017).

Productivity measurement issues and assumptions are examined in relation to their implications on industry policy in the Mozambican reality (OECD, 2017). The research intends to increase public awareness of the technical aspects of productivity debates and contribute to reduce the literature gap.

1.2. MOZAMBICAN BANKING SECTOR

Mozambique is a country located in the Southern region of Africa. Early in the 1970s after its independence from Portugal, the country followed a centralized economy, making all the import companies, including banks to become public entities (the government nationalized almost all banks in the country, in 1977, and only permitted Banco Standard Totta de Moçambique to remain private). In 1984 the country accepted assistance from the Bretton Woods institutions (joined IMF), and through its recommendations, many companies had to be privatized, as well as the creation of new enterprises. The banking sector was one of the boosted. The Central Bank was formally created in 1992 (Pateguana, 2016). From 1975 the Bank of Mozambique performed commercial functions until 1992, when the functions of commercial banking and central banking were separated, and new institutions emerged from then.

According to Bank of Mozambique, the supervisor (annual report, 2018), there were 19 commercial banks, operating in the country, until the end of the year, as follows:

1. **BCI - Banco Comercial e de Investimentos, SA** - is the country's largest bank, with a 40% market share. It is owned sixty percent by the Portuguese public bank Caixa Geral de Depósitos and 40% by small shareholders (http://www.bci.co.mz).

2. **MBIM – Millennium Banco Internacional de Moçambique, SA** – is the second largest bank in the country. This bank was formed in 2001 through a merger of Millennium BCP and Banco Comercial de Moçambique (http://www.millenniumbim.co.mz).

3. **Standard Bank (SB)** is a South African bank and the largest in Africa. The Standard Bank of South Africa Limited is a South African financial services groups and is Africa's biggest lender by assets. The company's corporate headquarters, Standard Bank Centre, is situated in Simmonds Street, Johannesburg. The bank now known as Standard Bank was formed in 1862 as a South African subsidiary of the British overseas bank Standard Bank, under the name The Standard Bank of South Africa (**http://www.standardbank.co.mz**).

4. **ABSA Bank** (former Barclays Bank). Absa Bank Mozambique, SA is part of Absa Group Limited, an African financial services group that aims to be the pride of the continent. Absa Group Limited is listed on the Johannesburg Stock Exchange in South Africa and is one of Africa's largest diversified financial services groups with a presence in 12 countries across the continent and around 42, 000 employees (**https://www.absa.co.mz/**).

5. **First National Bank** (**FNB) Mozambique** – is a subsidiary of FNB South Africa. Afrikaans: Eerste Nasionale Bank (ENB)) is one of South Africa's "big five" banks. It is a division of First Rand Limited, a large financial services conglomerate, which trades on the Johannesburg Securities Exchange (JSE), under the symbol: FSR. FNB is also listed on the Botswana Stock Exchange under the symbol FNBB and is a constituent of the BSE Domestic Company Index (**http://www.fnb.co.mz**).

6. **BancABC** (previously African Banking Corporation) was originally a British Overseas Bank, headquartered in London albeit with all branches overseas; main shareholders currently include the International Finance Corporation, Old Mutual, Botswana insurance Fund Managers and Citi Venture Capital. In 1999, ABC Mozambique was incorporated as BNP Ned Bank, a joint venture between the Brazilian BNP Paribas and Ned Bank of South Africa (**http://www.bancabc.co.mz/en/**).

7. **Société Générale Moçambique (SGM)** – former Mauritius Commercial Bank SA , is a subsidiary of The Mauritius Commercial Bank Limited, a Mauritius based bank (**http://www.societegenerale.co.mz**).

8. **Ecobank Mozambique** is a subsidiary of a pan-African bank Ecobank. In 2013, Ecobank entered the market by buying Banco ProCredit. The bank began operations in 1989. It operates as a universal bank, providing wholesale, retail, corporate, investment and transaction banking services to its customers in the Nigerian market. The bank divides its operations into three major divisions: (a) Retail Banking (b) Wholesale Banking and (c) Treasury & Financial Institutions. The bank also offers capital markets and investment banking services (**http://www.ecobank.com**).

9. **Socremo Microfinance Bank** is a Mozambique microfinance private bank. On 26 May 1998, Socremo was established in Maputo as a Sociedade de Créditos de Moçambique. Socremo was the result of a long process, led by the then Office for the Promotion of Employment (Gabin ete de Promoção do Emprego - GPE), aiming to transform GPE's social support project into a credit institution, in order to provide financial services to the low-income population who had no access to financial services in retail banking (**http://www.socremo.com**).

10. **Banco Nacional de Investimento, SA (BNI)** is a state National Investment Bank. BNI, SA, was established on June 14, 2010 and is the Mozambican development and investment bank, dedicated

to the financing of projects focused on innovation and contributing to the sustainable development process of Mozambique and boosting business sectors. The National Investment Bank is a privileged interlocutor not only with Mozambican companies and international investors, but also with national and international institutions responsible for providing development instruments and financial products (**http://www.bni.co.mz/**).

11. **CapitalBank - Mozambique SA (CBM),** is a bank controlled by the ICB Banking Group based in Switzerlandand specializes in emerging markets. It focuses on international bank services and foreign trade finance (**http://www.capitalBank.co.mz**).

12. **United Bank for Africa Moçambique, SA (UBA)**, is a leading pan-African financial services group headquartered in Nigeria, with operations in 20 African countries and offices in three global financial centers: London, Paris and New York. UBA operates in: Republic of Benin, Burkina Faso, Cameroon, Congo Brazzaville, Congo DRC, Ivory Coast, Gabon, Ghana, Guinea, Kenya, Liberia, Mali, Mozambique , Nigeria, Senegal, Sierra Leone, Tanzania, Chad, Uganda and Zambia (**https://www.ubamozambique.com/**).

13. **OPPORTUNITY Bank, SA** - is a microfinance bank. Opportunity Bank Mozambique, S.A. (BOM), now called MyBucks Bank Mozambique, S.A. ("MBC", "MyBucks Banking Corporation" or "Bank") is a commercial bank operating in Mozambique since 2005 and offers savings and investment products, microcredit, credit consumer credit, agricultural credit, small business credit, public sector employees, insurance, bank cards and electronic banking. The Bank has 13 branches, located in Maputo, Matola, Matendene, Beira, Dondo, Chimoio, Manica, Tete, Nampula, Nacala, Quelimane, Mocuba and Gurué, 4 ATMs in the main councils and representations in remote areas of Mozambique through technology known as mobile banking (**https://www.mbc.finance/**).

14. **Banco MAIS - Banco Moçambicano de Apoio aos Investimentos, SA**, provides credit and savings services to emerging Mozambican entrepreneurs, in particular, women. **Banco MAIS** is a commercial bank with a focus on Business Units networks in Maputo, Boane, Xai-Xai, Chimoio and Tete (**https://www.bancomais.co.mz/**).

15. **Banco Unico, SA** – is a subsidiary of Nedbank of South Africa (**http://www.bancounico.co.mz**).

16. **Banco Terra, SA -** is a National Private Bank, now in the process of merging with Moza Banco (**www.btm.co.mz**).

17. **Moza Banco, SA** - is a National Private Bank. It opened its doors for the first time in 2008. In 2011, the Espírito Santo Africa Bank (BES África), the current new Bank of Africa, integrated into the shareholder structure of Moza by acquiring 25.1% of the Bank's share capital whilst the Mozambique Capitals (the founder shareholder) retained its position as the largest shareholder with participations of 51%. In September 2016, as a result of the continued degradation of economic and financial indicators and the prudential situation of the Bank, the Central Bank of Mozambique intervened at Moza Banco, with the aim of protecting the interests of depositors and stakeholders, having appointed a Provisional Board of Directors who undertook the necessary actions to recover the activity and rescue the Bank's trust in the sector and market.

In June 2017, under the bank's recapitalization process, Kuhanha (Management Company of the Bank of Mozambique's Pension Fund) became part of the bank's shareholder structure, having injected the capital of MZN 8.17 million, corresponding to a participation of 79.3%.

In December 2018, Arise, became part of the shareholder structure of Moza, with a participation of 29.80%. Also, in December 2018, Moza acquired 100% of the shares of Banco Terra Mozambique (BTM), which conducted to the merger between the two institutions. (http://www.mozabanco.co.mz).

18. **Banco Letshego, SA –** Letshego Holdings Limited ("Letshego") was incorporated in 1998, is headquartered in Gaborone and has been publicly listed on the Botswana Stock Exchange since 2002. Today it is one of Botswana's largest indigenous groups, with a market capitalisation of approximately USD500mn, placing it in the top 50 listed sub-Sahara African companies (ex-South Africa), with an agenda focused on inclusive finance. It operates in eleven countries across Southern, East and West Africa (Botswana, Ghana, Kenya, Lesotho, Mozambique, Namibia, Nigeria, Rwanda, Swaziland, Tanzania and Uganda) (https://www.letshego.com/mozambique).

19. **Banco BIG Moçambique, SA -** Banco BiG Moçambique ("BiG Moçambique", "BiG" or "Banco") started its activities in March 2016, following the authorization granted by Banco de Moçambique in 2014 to establish a banking unit in the country (http://bancobig.co.mz/).

The number of institutions participating in the market suggests a higher competition in banking and seems that it will continue, since new competitors seek to enter in the country. For instance, BIG and MAIS just entered in the last two and three years, respectively, while MOZA and Terra are in the process of merging. That is why the performance analysis (Adhikari, 2017), appears to be very important, either for the regulator, or for the management practices assessment in the banking industry (Wanke, Barros & Emrouznej, 2016).

1.3. PROBLEM STATEMENT

While it is common, the evaluation of the efficiency of banks in the US and Europe, few studies are available about African banking (Wanke, Maredza & Gupta, 2017), and the same applies to Mozambique, suggesting a literature gap. From the consulted literature there is no record of the existence of studies about how efficient the banks address their mission of financial intermediation in Mozambique.

The study aims to assess the performance of the Mozambican banking industry, through efficiency and TFP, later, using statistical models (OLS), evaluate the variables impacting the TFP, in the period 2008-2018. The TFPCh are computed using DEA method and after, a regression helps to test, up to which extent the banking sector efficiency and productivity growth are affected by a set of selected variables.

1.4. STUDY RELEVANCE AND IMPORTANCE

When choosing a topic for research some factors should be taken into consideration such as the appropriateness of the researcher's possibilities taking into account the current available bibliographic material and its complexity. The researcher's capacity and education, his/her experiences in the field and professional experiences, previous knowledge and thematic relevance in the real context are also essential factors for the accomplishment of a research work. In this chapter we will address the relevance of the highlighted theme

After better understanding and assumption construction, the result will be a scientific platform, at disposal of INE - Mozambique as well as BM, to introduce in their large portfolio of data, the new product, to the country, extremely necessary and important in many areas of intervention (economics, politic, social, etc.).

The aim of the study is to trigger debates at local level on the issue.

A set of suggestions and recommendations are delivered, including better understanding of the relative importance of the banking sector in the Mozambican economy. This will help to make available (to spread) the knowledge among the compilers and the users of official statistics. The findings are also expected to enhance the transparency and efficient functioning of the sector. The determinants of banking efficiency are estimated using panel data analysis. Finally, not the least, being one of the few studies about the subject in the country, it will serve as basis for future researches.

1.5. STUDY OBJECTIVES

Through the study objectives we precisely define what we want to achieve with our search. It is precisely through them that the type and nature of the work, the methods to be employed and the works and documents to be studied are established. It is considered as characteristic the use of verbs in the infinitive, such as: verify, analyse, observe, determine, among others.

1.5.1. Main objective

The research intends to assess the Total Factor Productivity Change (TFPCh) and its determinants, in the Mozambican banking sector, in the period 2008 - 2018.

The study aims to compute and analyse the Malmquist Productivity Index (MPI), and find the main variables influencing it, in the Mozambican banks, using DEA and OLS models (Wanke et al., 2016).

1.5.2. Specific objectives

1. Using DEA, compute the bank's TFPCh, that is, compute the Malmquist Productivity Index (Total Factor Productivity);

2. Analyze the banking sector performance in the period;

3. Assess the determinants of efficiency and productivity in the Mozambican banking sector and investigate the extent of the influence (negative or positive), among a set of explanatory variables.

2. LITERATURE REVIEW

The literature review essentially attributes credibility to the work, making reference to the research and knowledge already built and published, situating the evolution of the subject and, thus, supporting the theme that is being studied. It is the analysis of the state of the art of the problem addressed. It is where is possible to analyse the existing theories on the theme, problem and based on this analysis a theoretical basis is built that serves as a foundation for the construction of new theories and / or knowledge.

This chapter is organized in three sections, namely: (i) Productivity concept, which is divided into (a) Efficiency measurement concept and (b) Malmquist Productivity Index (MPI), (ii) Non-performing loans (NPL) and (iii) Determinants of banking efficiency.

2.1. PRODUCTIVITY

A look at the productivity (Li, 2013) literature and its various applications reveals that there is neither a unique purpose for, nor a single measure of productivity (Chen & Yang, 2011; Zhu, Wang & Wu, 2016).

Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use (Coelli, Rao, O'Donnell & Battese, 2005; OECD, 2001). A measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs (ESA, 2010; SNA 2008).

The corporations are constantly challenged to innovate and create new ways of doing business, namely, enhancing product and service economic value (Mintzberg, 1971), knowing that economic activity can produce desirable and undesirable outputs, the late, normally called negative externalities in economic theory (Cheng & Zervopoulos, 2012).

As stated before, two economic theories guide the assessment of how good the firms are doing. Furthermore, there are two most prevalent frontier methodologies, the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA), applied to compute the total factor productivity (TFP) index (Chen, Delmas & Lieberman, 2015). The main reason is that the frontier methods enable an understanding of firm's performance deeper than the comparison of company profits. Besides that, DEA models use multiple inputs and multiple outputs to evaluate efficiency (Fare, Grosskopf, Norris & Zhang, 1994; Kar & Rahman, 2018).

Most of the existing studies focusing on banking efficiency and productivity using DEA (Adesina, 2019; Berger & Humphrey, 1992, 1997; Fukuyama & Weber, 2009a, 2009b, 2010; Holod & Lewis, 2011; Sufian, 2010; Wanke et al, 2016) use four approaches to address it:

(i) *Production approach* – banks are treated as an ordinary firm, whose duty is to maximize the profit or minimize the cost (Mansour & El Moussawi, 2019);
(ii) *Intermediation approach* – considers the asset transformation function, assuming that the bank uses deposits and other purchased inputs to produce different categories of bank assets such as loans and investments, measured by their monetary values (Karray & Chichti, 2013; Yannick, Hongzhong & Thierry, 2016);

(iii) *Asset approach* – Asset productivity ratios describe how effectively business assets are deployed. These ratios typically look at sales dollars generated per unit of resource. Resources can include accounts receivable, inventory, fixed assets, and occasionally other tangible assets (Sander & Haley, 2008, p. 174);

(iv) *Value added approach* - MFP indices show the time profile of how productively inputs are used to generate value added (OECD, 2001, p. 23).

This study adopted the intermediation approach and focuses on the Malmquist Productivity Index (Kar & Rahman, 2018; Rao, 2011), which permits to identify various sources of productivity growth: Efficiency change, Technical change, Scale efficiency change and Output and input mix effect (Casu, 2013; Lee, 2010; Walheer, 2019), to assess the productivity of the banking industry, in Mozambique.

2.1.1. Efficiency Measurement Concepts

Full efficiency in an engineering sense means that a production process has achieved the maximum amount of output that is physically achievable with current technology and given a fixed amount of inputs (Diewert & Lawrence, 1999).

However, recent studies on efficiency and productivity address it in different perspectives, that can be summarized as follows (Kar & Rahman, 2018):

- Efficiency studies based on accounting ratios: identifies important financial ratios and variables;
- Efficiency studies based on the non-parametric DEA technique: uses distance function to compute the efficiency;
- Efficiency studies based on the parametric SFA technique: uses stochastic frontier analysis, to assess the efficiency;
- Productivity studies using the Malmquist productivity index (MPI): mix efficiency change, again, computed through DEA;
- Studies on TFP decomposition: TFP growth for a multi-input and multi-output firm (O'Donnell, 2010).

Concerning the banking sector, several empirical researches, on bank efficiency, have been developed in the last decades (Nikolaidou & Vogiazas, 2017; Raphael, 2013; Tsumake, 2014; Zhao & Kang, 2015). Most of them use radial DEA models to evaluate efficiency, because it consists of multiple-inputs and multiple-outputs. It also allows efficiency to change over time and requires no priori assumptions on the specification of the efficient frontier (Zhao & Kang, 2015).

For example, Adesina (2019), using a panel of 339 commercial banks operating in 31 African countries over the 2005–2015 period, adopted the model to examine the effects of intellectual capital (IC) on technical, allocative and cost efficiencies and the findings were that there are strong evidence that IC exerts positive effects on bank technical, allocative and cost efficiencies.

Another study analysed the efficiency of Brazilian banks (Henriques, Sobreiro, Kimura & Mariano, 2018), using the intermediation approach (Zimková, 2014; Lindley, 1977), one of the main mechanisms used by several studies in other countries, and the findings were that, inefficiency of Brazilian banks is slightly more related to technical and administrative issues than to the scale of operations.

Metafrontier framework has been extended in several directions (Kerstens, O'Donnell & Woestyne, 2019), such as the transposition of the production to a cost frontier framework (Huang, Huang & Liu, 2014); the estimation of the Malmquist productivity indexes relative to metafrontiers, for a primal index and for a dual approach (Huang, Juo & Fu, 2015); as well as the introduction of more metafrontier efficiency decompositions (Kounetas, Mourtos & Tsekouras, 2009; Tsekouras, Chatzistamoulou & Kounetas, 2017).

Nevertheless, a recent study, conducted by Kerstens et al. (2019), argue that estimates of efficiency might contain potentially errors, thus they must be unreliable. Using what they call a refined methodology for nonparametric envelopment of non-convex metasets, they applied the methodology to a secondary data set to illustrate the potential errors associated with the currently established methods, and they found that the convexification strategy consisting in assuming a convex metaset generally leads to erroneous results.

A lot could be said, that is, different authors bring different views, and all of them make sense. Because of that, in this research, Malmquist Productivity Index (Banker, Charnes & Cooper, 1984), is adopted to measure the TFP, through DEA. The reason is because there is no consensus in the literature (Kar & Rahman, 2018; Henriques et al., 2018), on which model is best for evaluating banks. The second reason is that, it is probable the first research, using the methodology in the country, for that time horizon (2008 – 2018).

Therefore, DEA will permit to assess:

- ✓ *Technical efficiency*: treated as the ability of a firm to obtain maximal output from a given set of inputs (Coelli et al., 2005; Fare et al., 1994; OECD, 2001). Technical efficiency can be measured from two aspects - input and output: in the case of the given input, the technical efficiency is measured by the degree of output maximization; under the condition of the given output, the technical efficiency is measured by the degree of input minimization (Cheng, 2014; Farrell, 1957).
- ✓ *Allocative efficiency* as the ability of a firm to use the inputs in optimal proportions, given their respective prices (Coelli et al., 2005; Kar & Rahman, 2018). Also called *Cost efficiency* is a measure of how well a firm streamlines its operations and controls its administrative costs (Yimga, 2018).
- ✓ *Scale efficiency measure* - used to indicate the amount by which productivity can be improved by moving to the point of technically optimal productive scale (TOPS) (Coelli et al., 2005).

Combining the efficiencies, it will be possible to compute the MPI.

2.1.2. Malmquist Productivity Index (MPI)

Malmquist productivity index is defined as the methodology of using economic theory and mathematical statistics to measure the operational efficiencies of firms (Chen & Young, 2011).

MPI makes use of distance functions to measure productivity change (Caves, Christensen & Diewert, 1982; Rao, 2011; Walheer, 2019).

When measuring productivity change by identifying various sources of productivity growth, four components are used: Efficiency change, Technical change, Scale efficiency change and Output-Input mix effect (Coelli et al., 2005; Yannick, Hongzhong & Thierry, 2016).

Therefore, MPI depends upon four different distance functions, that is, if we have observed output and input quantity data, for a cross-section of firms, in periods s and t, we can identify the production frontier using DEA and use them in computing the distance needed (Rao, 2011).

Mathematically it can be written as follows[1]:

$$MPI = m_0(y_s, y_t, x_s, x_t) = \sqrt{\left(m_0^s(y_s, y_{t,} x_{s,} x_t) \times m_0^t(y_s, y_t, x_s, x_t)\right)} =$$

$$= \sqrt{\left(\frac{d_0^s(x_t, y_t)}{d_0^s(x_s, y_s)} \times \frac{d_0^t(x_t, y_t)}{d_0^t(x_s, y_s)}\right)} \qquad (1)$$

which represent the productivity of point (x_t,y_t), relative to (x_s,y_s).

Even though it is an old concept, continues being used successfully in recent researches. Thus, MPI was implemented in this study, to assess the TFPCh. A panel data set of 16 Mozambican commercial banks, during the period 2008 to 2018, was used. Doing that, the researcher hopes the study will contribute to the empirical literature.

2.2. NON-PERFORMING LOANS

Loans are created when creditors lend funds to debtors (ESA 2010; SNA, 2008). NPLs ratio in the present study correspond to the sum of total loans and leases past due 90 days or more, and non-accrual loans, divided by total loans (Ghosh, 2017).

Recall what was said before that, credit risk management, liquidity risk management, asset liability management (including long-term insurance and pension liabilities) and banking objectives are some of the most important challenges banks must handle, especially private commercial banks (Chamboko & Bravo, 2016; Nikolaidou & Vogiazas, 2017; Bravo, 2016; Bravo & El Mekkaoui, 2018; Ayuso et al., 2019, 2020).

The main reason of the recent global financial crisis was a rise in non-performing loans in the balance sheet of banks (Ghosh, 2017), which exposed them to high risks, with impact in the economy, especially in the reduction on the financing capability. Thus, non-performing loans are a critical component to impact the development of the banking industry (Zhu, Wang & Wu, 2015).

Because of that, some studies recommend that NPLs must be included as input (Drake & Hall 2003), during the calculations of the efficiency, but others suggest that they should be an undesirable output (Fukuyama & Weber, 2008; Guarda, Rouabah & Vardanyan, 2012).

In the present research, the most important is to show the relative influence of NPLs in the efficiency and productivity, so that, it was used as an explanatory variable in a regression model.

[1] See also in Mansour & El Moussawi (2019), Coelli et al. (2005) and other authors

2.3. DETERMINANTS OF BANKING EFFICIENCY

Literature review shows that there is no common consensus about the effects of banking efficiency determinants. Bank specific indicators and macroeconomic factors (Řepková, 2015), bank size, equity over total assets, loans-to-total assets, type of ownership, bank configuration (Akin, 2009; Chen, 2005; Grigorian & Manole, 2002; Isık & Hassan, 2002; Vu & Nahm, 2013), ROA and ROE (Košak & Zajc, 2006), are some variables considered.

Some studies consider the influence of various types of risk (Vu & Nahm, 2013), such as liquidity risk (Ariff & Can, 2008), credit risk (Berger & Mester, 1997; Yildirim & Philippatos, 2007) and management risk, with positive impact. However, other researchers found a negative relationship between the credit risk (Athanasoglou, Brissimis & Delis, 2008; Havrylchyk, 2006) and liquidity risk (Brissimis, 2008), and bank efficiency.

In this study and following the intermediation approach of the financial institutions (Yannick et al, 2016), as well as the fact that they are the widely used indicators in several researches (Zhao & Kang, 2015), eleven variables were elected as explanatory, as described in the section *data description*, in the methodology.

3. METHODOLOGY

It is the object of this chapter to present the selected methodology for the elaboration of this research work. As already mentioned, the main objective of this study is to compute and analyse the Malmquist Productivity Index (MPI), and find the main variables influencing them, in the Mozambican banks, using DEA and OLS models.

This chapter is divided into four sections: (i) Productivity calculation, (ii) DEA model, (iii) Research design and (iv) Data description.

3.1. PRODUCTIVITY CALCULATION

The production theoretical approach to productivity measurement offers a consistent and well-founded approach that integrates the theory of the firm, index numbers theory and national accounts (ESA, 2010; OECD, 2017; SNA, 2008).

This study adopted the index numbers approach in a production theoretic framework (Li, 2013), based on distance functions (MPI). This "growth accounting" technique examines how much of an observed rate of change of an industry's output can be explained by the rate of change of combined inputs. Thus, the growth accounting approach evaluates multifactor productivity (MFP) growth (Hall & Jorgenson, 1967; OECD, 2001).

3.2. DATA ENVELOPMENT ANALYSIS (DEA)

Efficiency and productivity are measured by using either a parametric (e.g., stochastic frontier analysis (SFA)) or a non-parametric approach (e.g., data envelopment analysis (DEA)), both of which have advantages and disadvantages (Kar & Rahman, 2018). DEA[2] is useful for measuring relative efficiency for a variety of institutions and has its own merits and limitations (Yannick et al., 2016).

DEA models are designed to maximize the relative efficiency of each DMU, provided that the relative efficiency scores acquired as such, for each DMU are also feasible for all the other, in the data set (Zimková, 2014). Another constraint for its better use is that, the number of DMUs must be higher than three times the sum of inputs and outputs.

To conduct a DEA estimation, inputs and outputs need to be defined (Coelli et al., 2005). At the same time, the literature says that it is almost impossible to fully capture the whole range of banking activities, due to their multiproduct nature (Řepková, 2015). Thus, four main approaches were developed and are used in theory and practice (intermediation, production, asset and profit), when defining the input-output relationship, within the financial institution behaviour (Kar & Rahman, 2018; Řepková, 2015).

In this study, the intermediation approach is considered to measure the efficiency and productivity of the Mozambican banking sector, from 2008 to 2018, combined with DEA method, because, as stated before, it does not require the specification of a functional form for the frontier (Zhao & Kang, 2015).

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[2] For more details about DEA check also Charnes (1978), Cheng (2014), Coelli et al., (2005), Emrouznejad & Cabanda (2015), Kar & Rahman (2018), among others.

With the intermediation approach (Sealey & Lindley, 1977; Zimková, 2014), the most commonly used approach in the European banking industry (Mansour & El Moussawi, 2019), is assumed that banks collect deposits to transform them, using labour, in loans. Thus, two inputs (labour and deposits), and two outputs (loans and net interest income) are considered.

Moreover, three options are available in the computer programs (Coelli, 1996), when running DEA models, namely:

a) The standard Constant Return to Scale (CRS) - used to calculate the technical efficiency (Fare et al., 1994);
b) Variable Return to Scale (VRS), - used to calculate the scale efficiency (Fare, et al., 1994);
c) The cost and allocative efficiencies (Fare, et al., 1994) and, the application of Malmquist DEA methods to panel data to calculate the Total Factor Productivity Change (Fare et al., 1994; Kar & Rahman, 2018).

The general formulation is as follows (Coelli et al., 2005; Weng, 2014):

Supposing there are **m** inputs and **q** outputs, a weighted input will be represented as

$$v = v_1 x_1 + v_2 x_2 + \cdots + v_m x_m \qquad (2)$$

And a weighted output will be represented as

$$u = u_1 y_1 + u_2 y_2 + \cdots + u_q y_q \qquad (3)$$

with the weight coefficients reflecting the relative importance between inputs and outputs.

The technical efficiency can be measured through calculation of the ratio of output to input.

Suppose we want to measure a set of technical efficiencies of **n** DMUs in total, denoted by DMU_j (j = 1, 2,..., n); each DMU has **m** inputs, denoted by x_i (i = 1, 2,..., m), and the input weight is represented as v_i (i = 1, 2,..., m); each DMU has **q** outputs, denoted by y_r (r = 1, 2,..., q), and the output weight is represented as u_r (r = 1, 2,..., q). The DMU to be currently measured is denoted by DMU_k, then its ratio of output to input will be represented as

$$h_k = \frac{u_1 y_{1k} + u_2 y_{2k} + \cdots + u_q y_{qk}}{v_1 x_{1k} + v_2 x_{2k} + \cdots + v_m x_{mk}} =$$

$$= \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad (4)$$

$$u \geq 0; v \geq 0;$$

$$i = 1,2, \ldots, m; \quad r = 1,2, \ldots, q$$

Note that, all efficiency values (**Eff**$_j$), obtained from DMU using the above weights are limited in the interval [0, 1], namely,

$$h_k = \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \leq 1$$

$$u \geq 0; v \geq 0; \tag{5}$$

$$i = 1,2, \dots, m; \qquad r = 1,2, \dots, q$$

This fractional model can be transformed to a linear programming model (Charnes & Cooper, 1962; Emrouznejad & Cabanda, 2015), for input and output orientation case. In the input-oriented model, DEA approach seeks the maximum possible proportional reduction in inputs while maintaining the outputs produced from each DMU. In the output-oriented model, seeks the maximum proportional increase in outputs produced with a given level of inputs. That is, four approache s are deducted:

1) CCR Model, based on Constant Returns to Scale (CRS), (Charnes, Cooper & Rhodes, 1978; Emrouznejad & Cabanda, 2015):

   1.1. Input-oriented CCR Model

$$Eff = \operatorname*{Min}_{u_r, v_i} \sum_{i=1}^{m} v_i x_{ij0}$$

s.t.

$$\sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad ; \forall j \tag{6}$$

$$\sum_{r=1}^{q} u_r y_{rj} = 1$$

$$u_r \geq 0; v_i v \geq 0 \qquad ; \forall r, \ \forall i$$

   1.2. Output-oriented CCR Model

$$Eff = \operatorname*{Max}_{u_r, v_i} \sum_{r=1}^{q} u_r y_{rj0}$$

s.t.

$$\sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad ; \forall j \tag{7}$$

$$\sum_{i=1}^{m} v_i x_{ij} = 1$$

$$u_r \geq 0; v_i v \geq 0 \qquad ; \forall r, \ \forall i$$

2) BCC Model, based on Variable Returns to Scale (VRS), (Banker et al., 1984; Emrouznejad & Cabanda, 2015):

2.1. Input-oriented BCC Model

$$Eff = \underset{\lambda,\phi,S_i^-,S_r^+}{\text{Min}} \phi$$

s.t.

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^+ \leq \phi x_{ij0} \qquad ;\forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^- = y_{rj0} \qquad ;\forall r \tag{8}$$

$$\sum_{j=1}^{n} \lambda_j u_r y_{rj} = 1$$

$$S_i^+ \geq 0; S_{r\ i}^- \geq 0 \qquad ;\forall r, \ \forall i$$

$$\lambda_j \geq 0 \quad ;\forall j$$

2.2. Output-oriented BCC Model

$$Eff = \underset{\lambda,\phi,S_i^-,S_r^+}{\text{Max}} \theta$$

s.t.

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^+ = x_{ij0} \qquad ;\forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^- = \theta y_{rj0} \qquad ;\forall r \tag{9}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

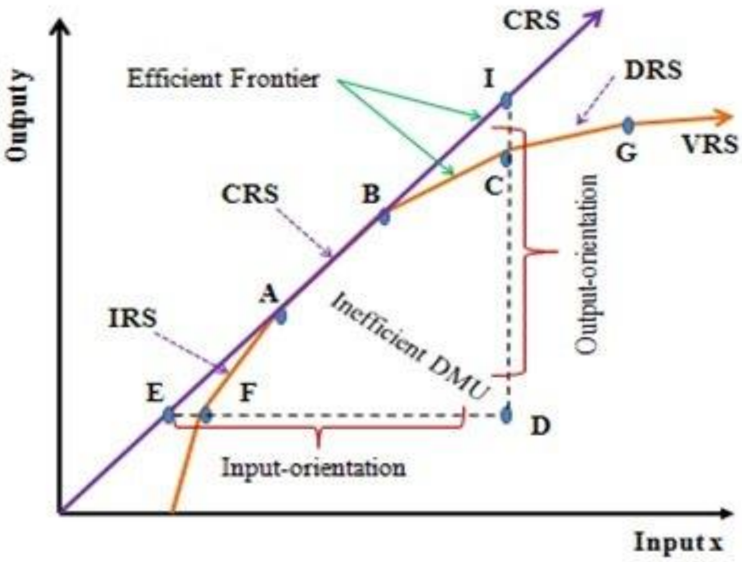
$$S_i^+ \geq 0; S_{r\ i}^- \geq 0 \qquad ;\forall r, \ \forall i$$

$$\lambda_j \geq 0 \quad ;\forall j$$

The main difference between the two models (CCR and BCC), is that, whereas in CRS models the input and output efficiencies are equals, in the VRS models normally they differ. For instance, Non Increasing Returns to Scale (NIRS) and Non Decreasing Returns to Scale (NDRS) are modelled by changing the constrain $\sum_{j=1}^{n} \lambda_j = 1$ to $\sum_{j=1}^{n} \lambda_j \geq 1$ and $\sum_{j=1}^{n} \lambda_j \leq 1$, respectively in Eq. (8) for input and Eq. (9) for output efficiencies.

Figure[3] 1 shows the different ways and approaches, when measuring efficiency. DEA method can construct a non-parametric envelopment frontier over the data points of all firms or observations that lie on or below the efficiency frontier (Emrouznejad & Cabanda, 2015).

Figure 1: Input & Output with Mixed CRS & VRS



Source: Dar (2017)

In the present research, the output-oriented Malmquist productivity change index was adopted[4], consistent with which it is assumed that there is a proportional increase of outputs, maintaining the same level of inputs (Isik, 2008; Isik & Hassan, 2003; Jaffry, Ghulam, Pascoe & Cox, 2007).

Back to the mathematical representation, the MPI reference to technology t is defined by Caves et al. (1982) as:

$$MPI = m_0(y_s, y_t, x_s, x_t) = \frac{d_0^s(x_t, y_t)}{d_0^s(x_s, y_s)} \qquad (10)$$

[3] Extracted in Dar (2017)

[4] Interested readers are referred to Coelli et al., (2005), and Cooper, Seiford & Tone (2007), among others, for more details about the MPI.

For the period t + 1 is:

$$MPI = m_0(y_s, y_{t+1}, x_s, x_{t+1}) = \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_s, y_s)} \tag{11}$$

The output based MPI is the geometric mean of Eq. (11) (Coelli et al., 2005):

$$MPI = m_0(y_t, y_{t+1}, x_t, x_{t+1}) = \sqrt{\left(\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_t, y_t)}\right)} \tag{12}$$

Where:

d_0^t is the distance function at time t,

d_0^{t+1} is distance function at time t + 1,

x is a vector of inputs,

y is a vector of outputs, and

m_0 is the Malmquist Productivity Index

Following Fare et al. (1994), the above formula can be decomposed into efficiency change and technological change, that is:

$$MPI = m_0(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} * \sqrt{\left(\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_0^t(x_t, y_t)}{d_0^{t+1}(x_t, y_t)}\right)} \tag{13}$$

The first factor is the efficiency change and the one inside sqrt is the technical change.

Therefore, if:

- $m_0 > 0$ means there is productivity growth;
- $m_0 = 0$, stagnation and
- $m_0 < 0$, productivity decline.

The scale efficiency change (SE) component (Ray & Desli, 1997), is defined by the distance function as:

$$SE_t(x_t, y_t) = \frac{d_{CRS}^t(x_t, y_t)}{d_{VRS}^t(x_t, y_t)} \tag{14}$$

CRS comprises the technology with constant returns to scale assumption and VRS a variable returns to scale.

Fare et al., (1998) extended the Eq. (14) to incorporate time and the scale efficiency change factor, as follows:

$$S\Delta(x_t, y_t, x_{t+1}, y_{t+1}) =$$

$$= \frac{SE_t(x_{t+1}, y_{t+1})/d_0^{t+1}(x_{t+1}, y_{t+1})}{SE_t(x_t, y_t)/d_0^t(x_t, y_t)} * \sqrt{\left(\frac{SE_{t+1}(x_{t+1}, y_{t+1})/d_0^{t+1}(x_{t+1}, y_{t+1})}{SE_{t+1}(x_t, y_t)/d_0^{t+1}(x_t, y_t)}\right)} \quad (15)$$

Thus, the MPI (m_0) can be decomposed as:

$$m_0 = \sqrt{\left(\frac{d_{VRS}^t(x_{t+1}, y_{t+1})}{d_{VRS}^t(x_t, y_t)} * \frac{d_{VRS}^{t+1}(x_{t+1}, y_{t+1})}{d_{VRS}^{t+1}(x_t, y_t)}\right)} * \sqrt{\left(\frac{SE_t(x_{t+1}, y_{t+1})}{SE_t(x_t, y_t)} * \frac{SE_{t+1}(x_{t+1}, y_{t+1})}{SE_{t+1}(x_t, y_t)}\right)} \quad (16)$$

Dar (2017) lists the strengths and weaknesses of DEA in the decision support system (DSS) as follows: **strengths** – (i) DEA can handle multiple inputs and multiple outputs; (ii) DEA doesn't depend priori assumptions regarding the functional form of inputs and outputs; (iii) DEA compares a DMU with the best performed peer; (iv) DEA is independent with respect to units of inputs and outputs. **weaknesses** – (a) the random noise can cause significant problem; (b) DEA is good at estimating relative efficiency of DMUs but it converges very slowly to absolute efficiency; (c) DEA is a nonparametric technique so that, doesn't much with other statistical testing techniques; (d) Since DEA is a linear programming based technique, for each DMU we have to solve separate LPP. In the large number of DMUs the computation is very difficult.

With this, the author wants to show that the methodology has its advantages and drawbacks, so that, more researches, using different approaches are strongly recommended to confront the results.

3.3. OLS MODEL

To determine which variables best explain the MPI (m_0) behavior along the period, the Gauss-Markov regression model (OLS), is recommended (Mansour & El Moussawi, 2019), where the dependent variable is the total factor productivity change (TFPCH) of individual banks derived from the MPI method Eq. (16).

The general formula of the OLS model is as follows:

$$\begin{aligned} \ln(TFPCh)_{jt} = {} & \beta_0 + \beta_1 \ln(NB)_{jt} + \beta_2 \ln(Emp)_{jt} + \beta_3 \ln(KLev)_{jt} + \beta_4 \ln(Imp)_{jt} \\ & + \beta_5 \ln(IR)_{jt} + \beta_6 \ln(ROE)_{jt} + \beta_7 \ln(ROA)_{jt} + \beta_8 \ln(TA)_{jt} \\ & + \beta_9 \ln(GDP)_{jt} + \beta_{10} \ln(TL))_{jt} + \beta_{11} \ln(TK)_{jt} + \beta_{12} \ln(NPL)_{jt} + \epsilon_{jt} \end{aligned} \quad (17)$$

where "β_i" $(i = 0,1, \ldots,12)$, are the parameters to be estimated by the model; "j" denotes the bank; "t" the examined time period, and ϵ_{jt}, the noise term.

The dependent and independent variables were transformed into logarithmic form due to the different nature and scale of the data, that is, to improve the OLS results (Costa & Costa, 2017).

The overall fitness of the model is assessed by the hypothesis H_o and H_1:

$$H_0: \beta_2 = \beta_3 = \beta_4 = \cdots = \beta_j = 0 \tag{18}$$

$$H_1: \ \exists \beta_i \neq 0 \tag{19}$$

The question that is tested is "do we have model or not?"

The decision statistics of this test is given by Eq. (20).

$$\frac{R^2/(K-1)}{(1-R^2)/(n-k)} \cap \ F\ (k-1, n-k) \tag{20}$$

where R^2 is the determination coefficient; $k-1$ is the number of parameters being tested; and n is the number of observations.

When rejecting the null hypothesis, we only are sure that at least one of the slopes is non-zero. This test and the individual significance tests are independent.

The best OLS model (Pina & Costa, 2019), is selected considering the coefficient of determination (highest adjusted R^2), the elimination of multicollinearity between independent variables and the significance of the regression coefficients (p-values of robust t-tests smaller than 0,05).

3.4. RESEARCH DESIGN

• **Strategic perspective:** Grounded theory

It was designed to assess the performance of the Mozambican banking sector, using a panel of data from 2008 to 2018.

• **Approach**: Quantitative deduction

Malmquist productivity index, using DEA method, was measured. The directional distance function and the metafrontier-Luenberger productivity indicator were used to measure the efficiencies and the total factor productivity. Then, through OLS regression method, was possible to evaluate the determinants of banking TFPCh from a set of chosen regressor variables.

• **Data collection**: Secondary data.

• **Time frame**: Longitudinal – observation from 2008 to 2018.

• **Error**: **Accuracy:** The data was collected from the financial statements of each DMU and from the Central Bank, thus, can be considered as accurate, because is accounting information.

• **Currency**: The national currency in Mozambique is Metical (ISO: MZN).

• **The Content of the Data**: financial statements of the banking sector institutions, with amounts and ratios, reporting the banks' performance in each economic year.

• **Software:** two computer programs were used: (a) first, a non-parametric DEA linear program (DEAP version 2.1), to estimate the productivity and efficiencies. These are: (a) technical change; (b) technical efficiency change; (c) scale efficiency change; and (d) (MPI) (Kerstens & Van De Woestyne, 2014; Yannick, Hongzhong & Thierry, 2016;); Secondly, R Studio software was used to run an OLS regression model, to assess the determinants of efficiency and productivity.

3.5. DATA DESCRIPTION

The data used in the study was obtained from the annual reports of the commercial banks, studies from AMB & KPMG Mozambique and the information from National Institute of Statistics (INE-Mozambique) and from the Bank of Mozambique (Central Bank), during the period 2008 – 2018.

In the light of Article 39 of the Law 1/92, of 3/1/92, BM Organic Law[5], all the participants (Financial Institutions), must regularly report data. Part of that data was used in this study.

3.5.1. Selection of variables

As already stated in the section 5.2, to conduct a DEA estimation, inputs and outputs must be defined. Since it is impossible to fully capture the whole range of banking activities, due to their multiproduct nature (Řepková, 2015), among the four main approaches developed and used in theory and practice (intermediation, production, asset and profit approaches), when defining the input-output relationship, within the in financial institution behavior (Adesina, 2019), an intermediation approach (Zimková, 2014; Lindley, 1977), the most commonly used approach in the European banking industry, was adopted, and consistent with this, it is assumed that banks collect deposits to transform them, using labour, in loans. It permitted to define the input and output variables (labour and deposits), and (loans and net interest income), respectively.

The labour is measured by the total costs with employees, covering wages and all associated expenses and deposits by the sum of demand and time deposits from customers, interbank deposits and sources obtained by bonds issued. Loans are measured by the net value of loans to customers and other financial institutions and net interest income as the difference between interest income and interest expenses.

To assess the variables impacting the MPI, independent variables are needed. For instance, the banking efficiency and productivity are concerned at the same time with the internal factors (for example, related to the organizational strategies proper to each bank), and external factors (reflecting the environment in which the bank operates) (Mansour & El Moussawi, 2019).

[5] "all institutions, subject to supervision of BM, are required to submit to the Bank, in accordance with the instructions transmitted by the Bank, the monthly balance sheets and other details regarding their situation and the operations they carry out".

The table 1 lists variables that seem to better explain the MPI of the Mozambican banks, selected for the regression (Řepková, 2015), using the Ordinary Least Square (OLS) method, the more appropriate (Mansour & El Moussawi, 2019) for this type of tests.

Table 1: OLS model independent variables

Variable description
i. **Bank size** - measured as total assets (**TA),** in MZN. The bank total assets are used to capture the possible efficiency benefits or disadvantages of bank size (Adesina, 2019). The expected sign of the coefficient is ambiguous since the variable can contribute positively or negatively, depending on the circumstances;
ii. **Level of capitalization** (in %) - is the ratio of equity to total assets (**KLev**). A high ratio of ***KLev*** is an indicator of a high bank capitalization that can positively affect the productivity, thus, a positive sign of the coefficient of this variable is expected (Ayadi, 2013);
iii. **ROA - return on assets** (in %), proxy of profitability. The expected result is that higher profitability should lead to a productivity gain (Mansour & El Moussawi, 2019). Thus, a positive coefficient should be associated (Adesina, 2019);
iv. **Impairment** (in %) - the ratio of loans to assets is used as proxy of credit risk (**Imp**). The excessive increase of credit risk can bring perverse result to the bank productivity (Mansour & El Moussawi, 2019). But on the other hand, a high ratio of ***Imp*** is associated with profits as it reflects good performance of bank assets (Ayadi, 2013). Thus, positive coefficient is expected for this variable;
v. **Transformation rate** (**TrR**) - represented by the ratio of loans to deposits (in %), used as proxy of liquidity risk. If the ratio is too high, it means that the bank may not have enough liquidity to cover any unforeseen fund requirements. Conversely, if the ratio is too low, the bank may not be earning as much as it could be (Investopedia). The expected sign of the coefficient is ambiguous;
vi. **Interest rate** (in %) - ratio of interest income to total loans (**IR**); Yannick, Hongzhong & Thierry (2016) state that interest rates affect how you spend money. When interest rates are high, bank loans cost more; People and business borrow less and save more; Demand falls and companies sell less, making the economy to shrink. If it goes too far, it can turn into a recession. When interest rates fall, the opposite happens. People and companies borrow more, save less, and boost economic growth. But as good as this sounds, low interest rates can create inflation. Too much money chasing too few goods. Thus for this variable we expect a negative coefficient associated;
vii. **Number of branches of individual bank** (**NB**) - should re-imagine branch design, resource levels, technology and automation availability, and ultimately, the purpose and role of the branch channel … a clear vision for the future role of branches within the institution's broader network — is critical to ensuring their relevance in the new era of banking. A positive relation is expected;

viii. **Number of employees of individual bank** (**Emp**) - Koutsomanoli-Filippaki & Mamatzakis (2013) conducted a research whose results indicate the existence of a negative relationship between bank performance and the liberalization of EU labour markets. However, when looking at the disaggregated components of the labour index, we find evidence that different forces are at play and that the liberalization of the minimum wage, hiring and firing regulations and the cost of dismissals could assert a positive effect on efficiency. A negative coefficient is expected for this variable;
ix. **ROE** - return on equity (in %), the proxy for bank capital adequacy. The expected sign for the coefficient is negative, because as bank capital adequacy requirements become rigorous, banks tend to diversify into different areas of investment which can negatively affect their efficiency (Adesina, 2019);
x. **NPL – non-performing loan** (in %) - leads to incidence of huge loss on banks (Ghosh, 2017), hence, the negative coefficient is expected; and
xi. **GDP – annual growth rate of the Gross Domestic Product** (in %) - used to assess the relationship between MPI and economic growth. Assuming that economic expansion stimulates the demand and supply of banking services, it is expected the direct relationship between the two variables (Adesina, 2019). A positive sign is expected to the coefficient associated to the GDP. For this purpose, nominal GDP growth rate was used.

3.5.2. Data summary

The table 2 reports the structure of the file containing the data for DEA and the descriptive statistics of the input and output variables.

Table 2: DEA Variables Summary (values in millions of MZN)

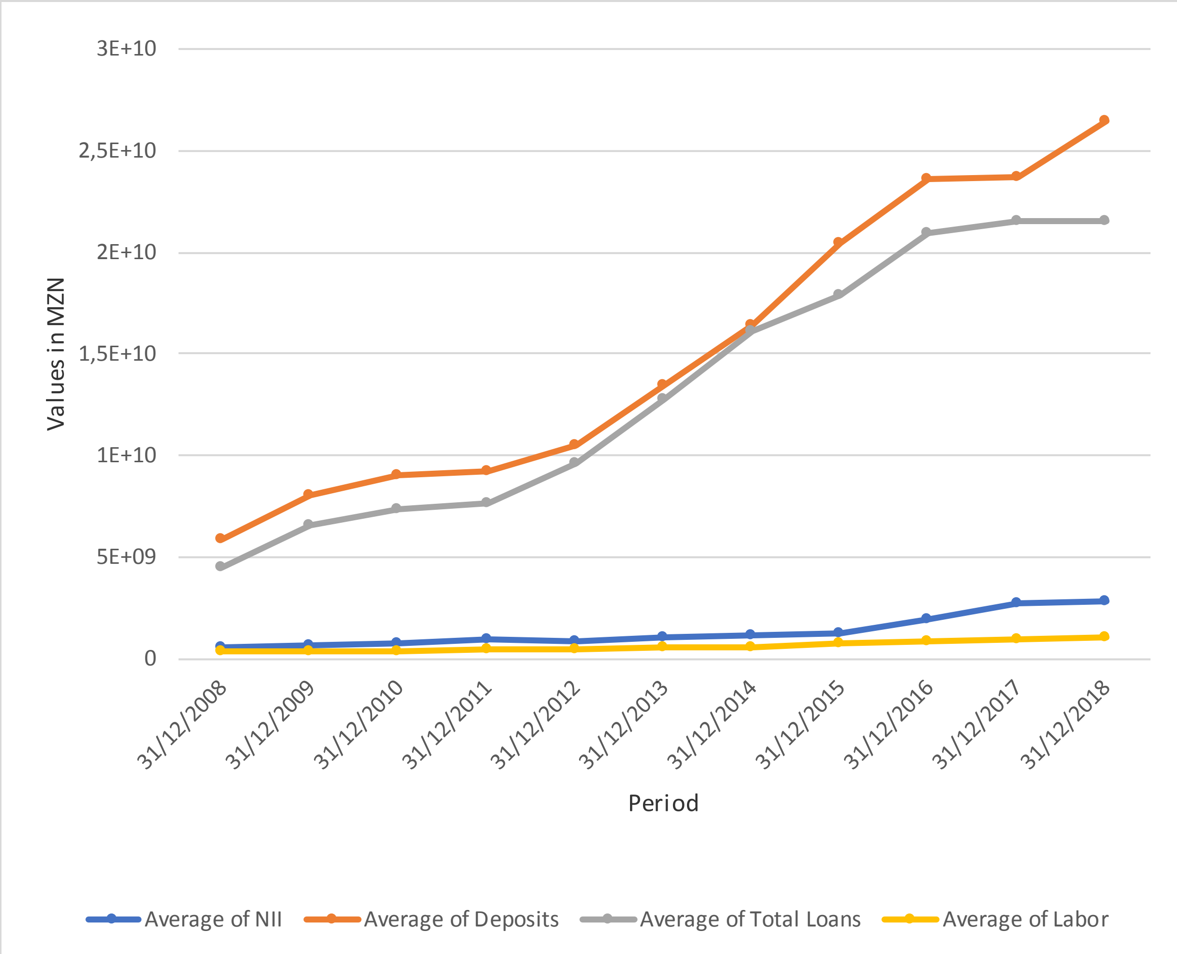
Description	NII	Loans	Labour	Deposits
Min	-1.2672E+01	7.6405E-02	2.7149E+01	3.0059E+01
1st Qu.	7.9080E+01	6.6200E+02	1.0830E+02	8.6490E+02
Median	4.3516E+02	2.9047E+03	2.0298E+02	2.9096E+03
Mean	1.3451E+03	1.3791E+04	5.9580E+02	1.5689E+04
3rd Qu.	1.2350E+03	1.2980E+04	6.9520E+02	1.7190E+04
Max	1.3148E+04	1.0617E+05	3.7785E+03	1.1577E+05
StDev	2.3285E+03	2.2998E+04	7.7478E+02	2.6536E+04

Source: author's preparation based on data

The values are denominated in million Monetary Units, in the case, Meticais (MZN), the local currency.

The graph in figure 2 shows the averages per year, of the same (input and output) variables.

Figure 2: DEA variables averages 2008 – 2018



Source: author's preparation

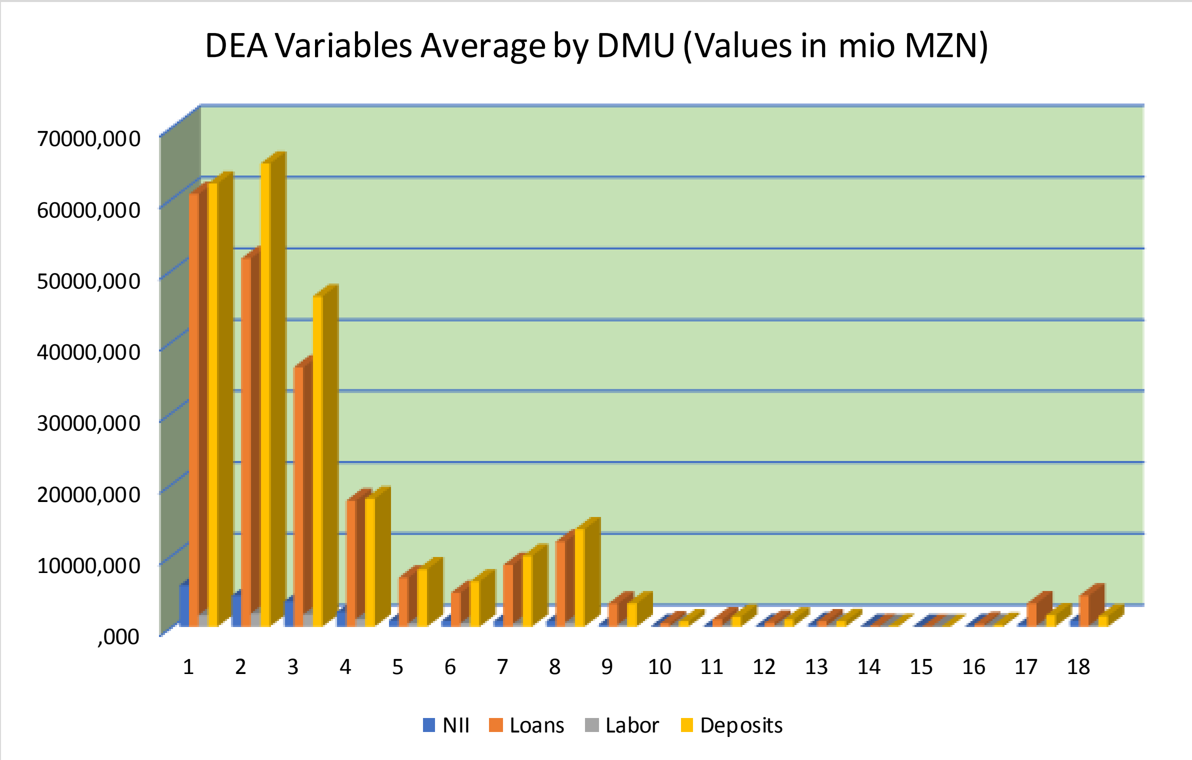
3.5.3. Data treatment

a) DEA Variables

The figure 3 shows the average values, per bank, of the four variables elected to assess the TFPCh. Due to excess of missing values and their relative insignificant weight in the market, three banks were not included (BIG, UBA and BTM). Four banks are observed from the time they entered the market (UNICO: 2010, BNI: 2011; LETSHEGO: 2011 & MAIS: 2014).

Finally, historic data is associated with the banks that bought participations from existing partners (ECOBANK=PROCREDIT; CAPITAL BANK=ICB; MYBUCKS BANK=OPPORTUNITY BANK & ABSA=BBM).

Figure 3: Average values of input & output variables (for DEA), per DMU



Source: author's preparation

For the TFPCh computation, DEA window program (DEAP 2.1) was used, under the assumptions of intermediation approach, output oriented and Malmquist Productivity Index analysis to estimate efficiency under the assumptions[6] of constant and variable returns to scale.

b) OLS model variables

Among bank specific indicators and macroeconomic factors (Řepková, 2015), the study intends to confirm, via OLS regression, which of them have a strong impact on their performance, to help the champions to manage the scarce resources (Sufian, 2011), to their best uses during the production of services and goods (Isik & Hassan, 2003; Sufian, 2011), as well as better understanding of the Mozambican banking sector catalytic

The structure of the file and the descriptive statistics of the data used to run OLS model are summarized in table 3.

[6] Note that VRS/CRS option in DEAP instruction file has no influence on the Malmquist DEA, because both are used to calculate the various distances that are used to construct MPI (Coelli, 2005)

Table 3: OLS variables summary

Description	TFPCh	NB	Emp	TrR	KLev	Imp	IR
Min	-3.7680E+01	1.0000E+00	3.0000E+00	2.3487E+01	-1.0029E+01	3.6427E+00	1.6852E+00
1st Qu.	0.0000E+00	4.0000E+00	6.6500E+01	6.4000E+01	1.0000E+01	4.5000E+01	1.1000E+01
Median	7.0000E+00	1.4000E+01	2.9300E+02	8.8447E+01	1.7297E+01	6.4430E+01	1.7570E+01
Mean	1.1614E+01	3.4217E+01	5.8706E+02	1.0449E+02	2.1475E+01	6.3688E+01	2.5403E+01
3rd Qu.	1.6250E+01	3.6250E+01	7.3720E+02	1.0500E+02	2.4000E+01	7.7000E+01	2.7000E+01
Max	8.1000E+01	2.0000E+02	3.0090E+03	5.6854E+02	9.7999E+01	1.3025E+02	1.2578E+02
StDev	1.6835E+01	4.9564E+01	7.2755E+02	7.3885E+01	1.6608E+01	2.1351E+01	2.2763E+01

Description	PB	ROE	ROA	TA	GDP	TL	TK	NPL
Min	0.0000E+00	-2.1133E+02	-7.4900E+02	1.3858E+08	3.4282E+00	4.7039E+07	-2.7754E+09	0.0000E+00
1st Qu.	6.6780E+07	8.0000E+00	1.0000E+00	1.2460E+09	4.0000E+00	7.5620E+08	2.2060E+08	1.0000E+00
Median	4.2409E+08	1.1866E+01	1.9200E+00	5.6845E+09	6.7233E+00	3.8707E+09	9.7153E+08	3.8000E+00
Mean	2.0060E+09	2.9275E+00	-4.3980E+00	2.1509E+10	5.9835E+00	1.8311E+10	3.1830E+09	5.7671E+00
3rd Qu.	1.5710E+09	2.4250E+01	5.0000E+00	2.2740E+10	7.0000E+00	1.9520E+10	2.5610E+09	7.0000E+00
Max	1.6462E+10	5.1159E+01	7.9678E+00	1.5466E+11	7.3985E+00	1.3913E+11	3.3566E+10	3.9000E+01
StDev	3.4826E+09	3.2464E+01	5.9341E+01	3.5383E+10	1.5282E+00	3.0427E+10	5.5396E+09	6.1709E+00

Source: author's preparation

When running the Gauss-Markov model, the simultaneous use of a group of explanatory variables may lead to multicollinearity problems (Adesina, 2019). Thus, it is recommended to carry out tests before running the regression, to check the existence or not, of the phenomena, that is, to find out whether there is potential multicollinearity problem in the data. For that purpose, a correlation was run, and the result is shown in figure 4.

From the correlation matrix shown in the figure 4, is possible to observe that some variables may be highly correlated, which conducts to the collinearity. Using these pairs of variables violates one of the six conditions (proprieties) of the OLS model (Gauss–Markov theorem): Just to refresh:

(i) $\mathbf{Y} = \boldsymbol{\beta}\mathbf{X} + \boldsymbol{\epsilon}$,

That is, the model is itself a linear combination. Where each letter represents a matrix, namely: Y= explained variable, β = the parameters to estimate, X= explanatory variable and ϵ= the residuals;

(ii) $\mathbf{E}[\widehat{\boldsymbol{\beta}}] = \boldsymbol{\beta}$ - The estimators are said to be unbiased;

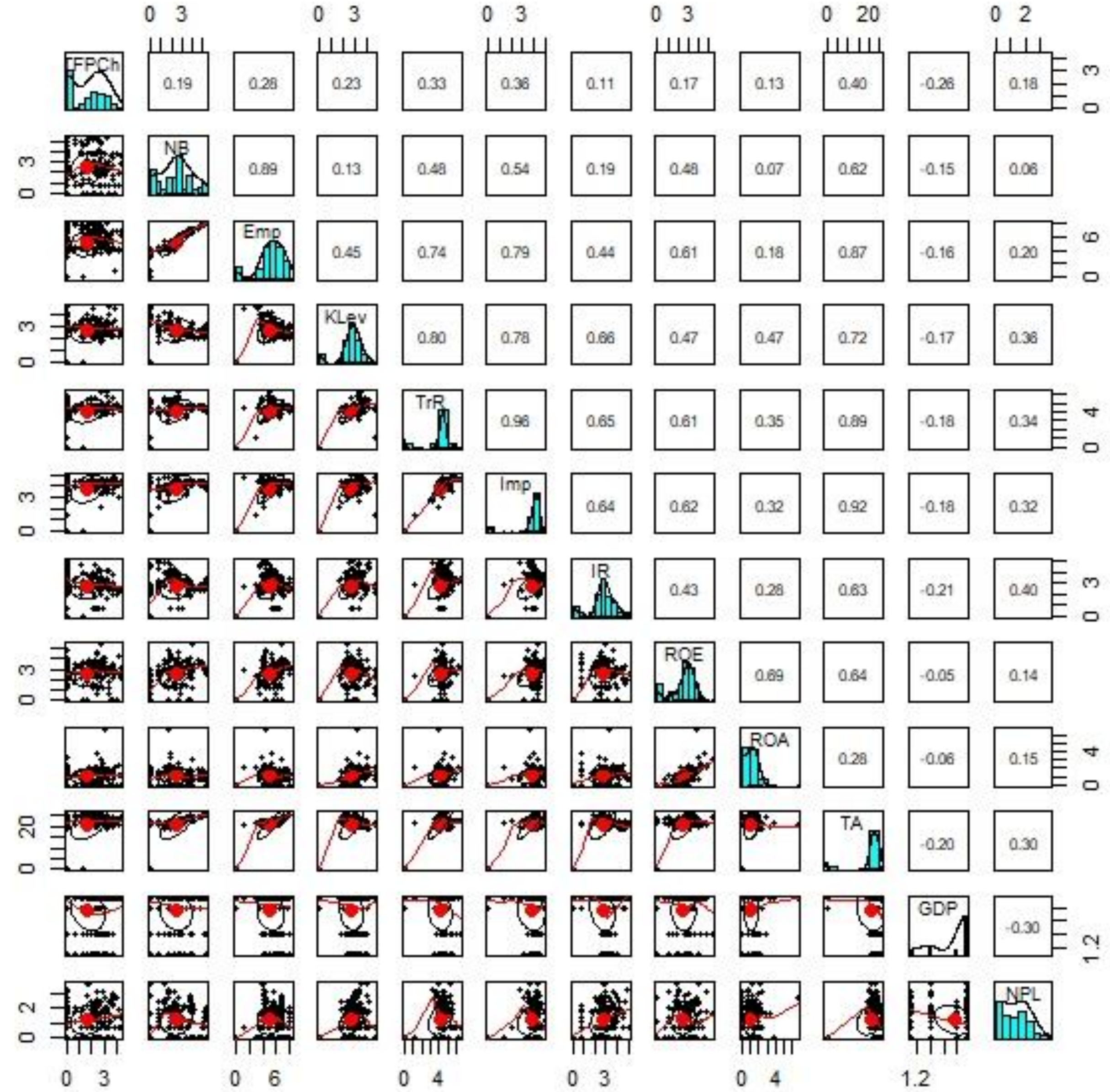
(iii) $\mathbf{E}[\boldsymbol{\epsilon}] = \mathbf{0}$, the errors are uncorrelated;

(iv) $\mathbf{Var}[\boldsymbol{\epsilon}] = \boldsymbol{\sigma}^2 * \mathbf{I}$, meaning that that the variance of the residuals is constant;

(v) The explanatory variables(**X**), are linearly independent, that is, the sample data matrix must have full column rank. A matrix is said to have full rank if its rank equals the largest possible for a matrix of the same dimensions, which is the lesser of the number of rows and columns;

(vi) $\boldsymbol{\epsilon} \cap \mathbf{N}(\mathbf{0}, \boldsymbol{\sigma}^2 * \mathbf{I})$ – the residuals are independently identically distributed (i.i.d).

Figure 4: Pairs of OLS variables



Source: author's preparation

In the present study, the number of branches (NB) and the number of employees (Emp) are highly correlated. The same happens with the pairs transformation rate (TrR) and impairment (Imp), total assets (TA) and impairment (Imp), and so on. To solve the problem, the less significant variables were removed (ignored from the model), successively, until the best fit was achieved. It was done, using the stepwise regression function.

4. RESULTS AND DISCUSSION

For Hérbert (2005, 117-118), "the process of organizing data is about condensing, then organizing, structuring or decomposing, to finally present the resulting relationships, or structures".

In qualitative studies, the researcher begins the analysis while collecting the data, so that questions that are unanswered can be answered or clarified before the end of data collection.

Recall that in the present research the quantitative deduction was implemented and the DEAP version 2.1 window program was used, under the assumptions of intermediation approach, output oriented and Malmquist Productivity Index.

DEA results

The table 4 presents the annual means of efficiencies and TFPCh (MPI), obtained along the period, for a sample of 12 DMU. The bottom line of the table shows the average of the scores, that is, negative performance of the sector in the period.

Table 4: DEA Outputs (TFPCh)

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS					
year	effch	techch	pech	sech	tfpch
2	0.957	0.977	0.977	0.980	0.935
3	0.998	0.974	0.986	1.013	0.971
4	1.037	0.926	0.968	1.071	0.960
5	0.952	1.047	0.989	0.963	0.997
6	1.020	1.092	1.023	0.998	1.114
7	1.032	0.897	1.015	1.017	0.926
8	1.015	0.941	1.053	0.964	0.955
9	1.095	1.056	1.040	1.052	1.156
10	0.909	1.165	0.946	0.960	1.059
11	0.977	0.923	0.960	1.017	0.901
Mean	**0.998**	**0.996**	**0.995**	**1.003**	**0.994**

Source: author's preparation

Note: effch =Technical efficiency change; techch=Technological efficiency change; pech=Pure efficiency change; sech=Scale efficiency change; tfpch=Total factor productivity change (MPI).

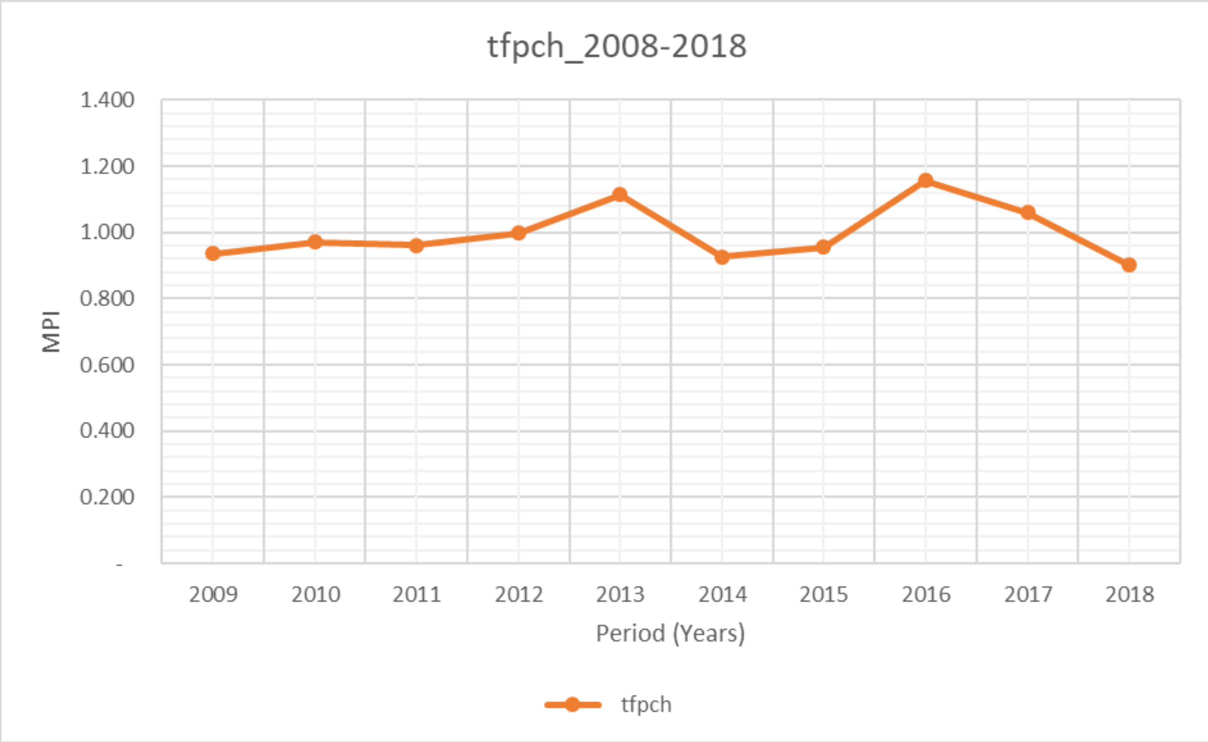
From the description in the methodology, we know that scores less than one mean negative performance whereas the contrary indicates the positive. Hence, in the periods 6, 9 and 10 (2013, 2016 & 2017), were observed positive values of productivity changes (last column), of 11,4, 15.6 and 5.9 percent, respectively.

The high value occurred when all components registered positive changes in efficiencies (in 2016).

The scale efficiency had an average score of 1.003, which suggests the perfect competition of the DMU in the market. The rest of the efficiencies did not perform well, since their average scores were less than 1.

The figure 5 presents graphically the evolution of the MPI over the decade in study. From the graph we can see that only in three years (year 6, year 9 and 10) the banks had positive productivity change of 11.4, 15.6 and 5.9 percent, respectively. The rest of the years the banks registered negative values of MPI.

Figure 5: Evolution of MPI from 2008 to 2018



Source: author's preparation

The table 5 resumes the same information, in the firm's perspective, that is, the efficiency means of each DMU (the performance of the 12 banks operating in the Mozambican Market, in the period between 2008 and 2018).

Looking to the individual performance, in the sample of 12 banks, the results indicates that the system had a negative overall score, even though many DMU had MPI greater than 1, meaning a positive percentage of change in TFP.

Individually, Millennium BIM and BCI had good results, mainly due to their investment in technology (positive values in techch).

Standard Bank and BCI performed well in the four efficiency components in the period.

FNB, ABC and Societe Generalle almost did well, despite failing in one of the components.

Absa (BBM), Mozabanco, Socremo and Mybucks are the banks that contributed negatively, with scores below 1, in all components of efficiencies, for the poor performance of the system in the period.

The rest did well in some components and negatively in others.

Table 5: Firm means of MPI

MALMQUIST INDEX SUMMARY OF FIRM MEANS					
Firm	**effch**	**techch**	**pech**	**sech**	**tfpch**
MBIM	1.000	1.052	1.000	1.000	1.052
BCI	1.009	1.061	1.002	1.007	1.070
SB	1.055	1.036	1.054	1.000	1.093
BBM	0.958	0.995	0.970	0.987	0.953
FNB	1.021	0.999	1.000	1.021	1.019
ABC	1.010	1.011	0.994	1.016	1.022
MOZAB	0.964	0.983	0.974	0.989	0.947
SGM	1.062	1.020	1.074	0.989	1.084
ECOBANK	1.012	0.995	1.011	1.001	1.007
CBM	0.996	1.017	0.927	1.075	1.013
SOCREMO	0.958	0.927	1.000	0.958	0.889
MBC	0.938	0.876	0.944	0.994	0.822
Mean	**0.998**	**0.996**	**0.995**	**1.003**	**0.994**

Source: author's preparation

Table 6 resumes the performance of 12 banks operating in the Mozambican Market, between 2008 – 2018, in percentage of change. On average, the banks had a negative percentage of change, suggesting that they are not living of intermediation process which consists in transforming the collected deposits, through labour, into loans and NII.

Table 6: Changes in productivity per year

Description	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
MBIM	5.20	-1.80	15.20	20.60	4.30	-53.50	133.20	-1.30	7.70	-3.90
BCI	14.40	-3.80	-16.40	20.90	17.60	-12.60	-45.70	150.00	72.30	-26.60
SB	15.70	-6.80	14.20	24.40	0.50	7.80	18.70	16.00	13.50	-6.10
BBM	-2.90	-1.00	-1.00	-10.30	9.30	-1.10	-20.50	7.80	-22.00	0.40
FNB	-14.40	-9.10	5.10	37.60	10.80	26.00	-14.50	-4.10	5.90	-11.20
ABC	-14.60	13.20	15.40	-32.90	47.40	18.90	0.90	8.40	20.70	-28.50
MOZAB	-49.60	19.20	22.10	-4.50	-14.20	9.40	14.60	-19.80	5.40	-8.60
SGM	23.20	-8.30	53.00	-3.90	14.10	202.20	-65.70	0.60	29.50	-12.60
ECOBANK	-14.10	-8.00	-23.00	-16.90	58.70	11.80	-9.90	-9.80	50.80	-2.70
CBM	10.70	-2.40	11.70	-0.70	3.00	23.70	6.40	49.50	-45.30	-14.20
SOCREMO	3.70	-1.60	-54.40	-23.50	-2.60	-49.20	8.70	69.70	-6.30	1.10
MBC	-26.20	-18.50	-36.80	10.70	6.50	-73.70	35.60	-3.70	-10.00	1.10
AVERAGE	**-6.50**	**-2.90**	**-4.00**	**-0.30**	**11.40**	**-7.40**	**-4.50**	**15.60**	**5.60**	**-9.90**

Source: author's preparation

Although there have been some moments of peak, in general the system registered poor productivity changes.

The trendline in figure 6 (the graphic representation of the bottom line of the table 6), shows an increasing tendency of the TFPCh along the period. However, in average the productivity changes registered negative values.

Table 7: Efficiencies scores from DEAP

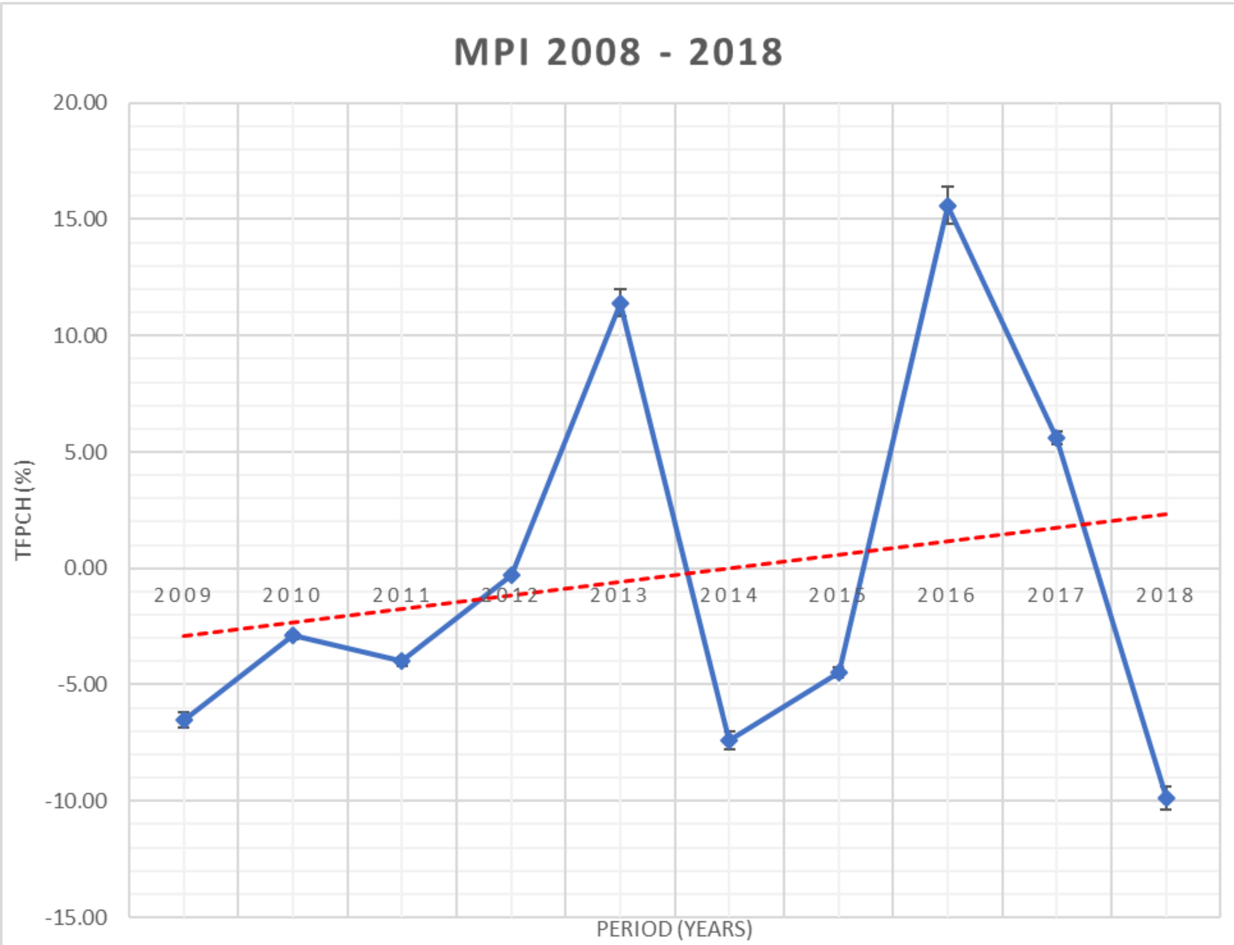
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
effch	-4.30	-0.20	3.70	-4.80	2.00	3.20	1.50	9.50	-9.10	-2.30
techch	-2.30	-2.60	-7.40	4.70	9.20	-10.30	-5.90	5.60	16.50	-7.70
pech	-2.30	-1.40	-3.20	-1.10	2.30	1.50	5.30	4.00	-5.40	-4.00
sech	-2.00	1.30	7.10	-3.70	-0.20	1.70	-3.60	5.20	-4.00	1.70
TFPCH	**-6.50**	**-2.90**	**-4.00**	**-0.30**	**11.40**	**-7.40**	**-4.50**	**15.60**	**5.90**	**-9.90**

Source: author's preparation

The table 7 presents the TFPCh (MPI) decomposed in efficiencies (summary of annual means). The scenario is the same, that is, the scores (exhibiting an inconsistent behaviour), indicate that banks were not efficient in the intermediation process, during the period.

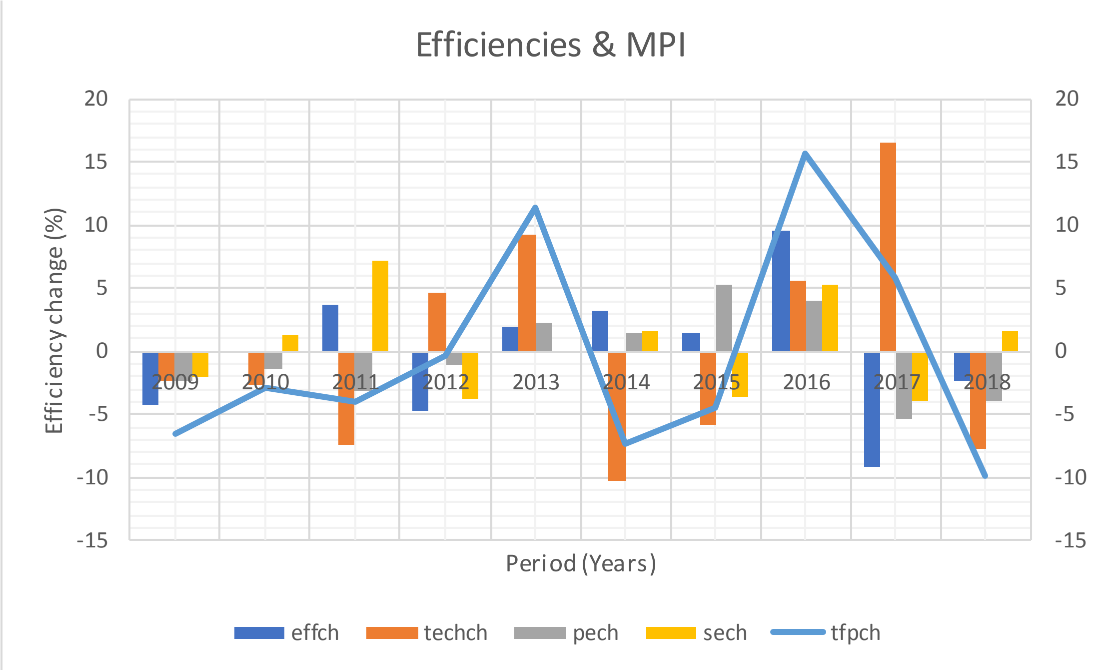
The figures 6 and 7 show the graphics representation.

Figure 6: TFPCh, graphics view



Source: author's preparation

Figure 7: Graphic view of the efficiency scores



Source: author's preparation

The figure 7 shows how well the banks performed looking to various efficiencies. Clearly, technical efficiency change and technology change are the components of the processes that most contributed to the behaviour of the TFPCh.

<u>OLS model</u>

Before running the regression, a multicollinearity test was made which dictated the exclusion of three explanatory variables: number of brunches (NB), transformation rate (TrR) and NPL.

Through stepwise regression function, the less significant or non-significant variables were dropped from the model, and the best fit was found with eight out of eleven proposed independent variables.

Table 8: OLS regression model estimates

Model variable	Coefficient	Std. Error	t-value	p-value
Intercept	1.72781	0.66262	2.608	0.009945
Emp	-0.39394	0.10539	-3.738	0.000254
Klev	-0.66113	0.19644	-3.365	0.000948
Imp	0.38647	0.21223	1.821	0.070393
IR	-0.34827	0.10705	-3.253	0.001381
ROE	-0.41462	0.15148	-2.737	0.006869
ROA	0.50279	0.17424	2.886	0.004423
TA	0.25567	0.04888	5.231	5.00E-07
GDP	-0.86196	0.30417	-2.834	0.005167

Source: author's preparation

The best fit is given by the Eq. (18):

$$\ln(TFPCh)_{jt} = \mathbf{1.72781} - \mathbf{0.39394}\, ln(Emp)_{jt} - \mathbf{0.66113}\ln(KLev)_{jt} + \mathbf{0.38647}\, ln(Imp)_{jt} - \mathbf{0.34827}\ln(IR)_{jt} - \mathbf{0.41462}\ln(ROE)_{jt} + \mathbf{0.50279}\ln(ROA)_{jt} + \mathbf{0.25567}\ln(TA)_{jt} - \mathbf{0.86196}\ln(GDP)_{jt} \quad (18)$$

Three of the independent variables (impairment, ROA and total assets) impacted positively and the other five (number of employees, level of capitalization, interest rates, ROE and GDP) had negative influence on the dependent variable (MPI). It means that all the variables had the expected behaviour minus the GDP.

The β value, except the intercept, means that, maintaining the other parcels constant, 1% variation of the respective (associated) variable, imply a β_i variation in the TFPCh.

Unexpectedly, NPL had no significant influence in the productivity assessment.

The expected sign for the coefficient associated with GDP was supposed to be positive, but incomprehensively it is negative.

General overview

The banking sector in Mozambique was dominated, during the period, by the top three banks namely Millennium Banco Internacional de Mozambique (MBIM), Banco Commercial e de Investimentos (BCI) and Standard Bank SA (SB), which had held more than 70% of the total market deposits and loans (KPMG, 2019).

The purchasing of shareholding in already existing financial institutions seems to be the strategy adopted by most of the international and regional financial institutions in entering the Mozambique Financial Market.

Looking to the evolution of the productivity changes in the period, we observe two good moments (2013 and 2016), with 11.4 and 15.6 percent, respectively. In 2013, the interest rates charged by commercial banks recorded an overall drop in rates for both active and passive operations (KPMG, 2013). This may be the factor which contributed to decrease the cost of money, making the people and companies to borrow more, save less, and boost economic growth.

Before that, the main macroeconomic and financial indicators maintained stable allowing the country to grow in average between 6 and 7 percent, mainly due to the following:

- The Metical (local currency), has shown a steady evolution since 2011;
- The total assets for the banking sector registered a significant growth;
- The strong demand for loans, by companies for the funding of infrastructure as well as individuals for consumption and acquisition of fixed assets;
- The return on equity ratio (ROE) varied moderately with each individual player. The same fluctuations were noted in the return on assets ratio (ROA);
- In line with its role as the regulator in the market, the Bank of Mozambique issued a set of pieces of Legislation which contributed to a stable level of inflation and interest rates.

In the 2016 the country registered an increase in Foreign Direct Investment in infrastructures and mining sector as well as the capital gains realised on the exploration/extraction of oil and gas.

From 2015 onward, the donners community stopped to support the government budget due to the not declared debts. This and other factors, namely, the natural disasters, took the country to recession.

The overall fitness test

Regarding the validation of the OLS, F-test for linear regression was used to test the significance of the independent variables in a multiple linear regression model. For that, several exploratory Ordinary Least Squares (OLS) regressions were undertaken in order to select the most relevant and appropriate explanatory variables.

The F-statistic presents a p-value of 6.521e-12, suggesting that the model is robust. As the *p-value* is very small (p-value << 0.0001), the decision is to reject the null hypothesis of general nullity of all the slopes (H_0), from the Eq. (18) and Eq. (19), that is, there is a significant relationship between the variables in the linear regression model of the data set.

5. CONCLUSIONS

The present research tries to fill an important gap in the literature of Mozambican banking sector efficiency by investigating the performance measured by the MPI and its components, namely technical, technological, pure and scale efficiencies, through DEA.

Our sample consisted of 16 commercial banks operating in the country over the period between 2008-2018. The OLS model was used to assess the variables impacting the productivity, through stepwise technique. F-test was used to ensure the robustness of the regression model.

To the best of our knowledge, that is, from the consulted literature, there is no record of the existence of studies about how efficient the banks address their mission of financial intermediation in Mozambique, meaning that this is the first ever study that analyses the effects of various efficiencies on banking system productivity.

Emrouznejad & Cabanda (2015) recommend caution in the interpretation of DEA results, according to them, to avoid giving wrong signals and providing inappropriate recommendations.

But based on the present research's assumptions and results given by the models, the following can be said:

- Using the described methodology (DEA - MPI) and the Mozambican banking system data for the period 2008-2018, the result was the negative global growth rate in all tested scenarios, namely, -0.60 percent (with 12 banks) and -1.02 percent for a sample of 16 DMU. Annex 7.1. reports three scenarios of DEAP outputs divided into three intervals: the first, from 2008 to 2010, with a sample of 12 banks; the second, from 2011 to 2013, with a sample of 14 DMU and finally, from 2014 to 2018, with 16 DMU;
- It suggests that the Mozambican banking sector performance in the period was not good, that is, banks are no longer embraced to their traditional core business (perhaps they may have introduced new types of business processes, or due to the corruption which affects the country in almost all sectors, governance or even the excessive taxation to their clients). The scores of the efficiencies indicate that banks were inefficient in the intermediation process during the period;
- The OLS model confirmed that eight out of eleven elected variables, in the case, number of employees, impairment, level of capitalization, interest rate, ROA, ROE, total assets and GDP had strong impact in the bank's performances. However, the GDP growth rate presents a strange behaviour. For instance, instead of having the direct relationship with the productivity changes, it appears to be one of the variables affecting negatively the banking industry performance in the period, together with interest rate and the number of employees. Annex 7.2 shows the regression model outputs, with all the statistics features.

<u>Limitations and recommendations for future works</u>

One of the problems all researchers face when addressing any study in Mozambique is the availability of data. The same happened with the present research.

Suggestions for future research include:

- ✓ More studies should be carried out for deeper understanding, that is, either to confirm the present results, or to bring new findings about the Mozambican banking system;
- ✓ Due to the nature of the banking activities, which can carry several dangers, the supervisor is challenged to follow tightly the phenomena;
- ✓ Monetary policy makers are called to join the challenge as well, to check the viability of the transmission mechanism;
- ✓ The champions have their rule in the process, for the stability of the sector and the return of their investment;
- ✓ The new advent of information system (IS) generates new types of business processes, new products, etc., raising the issue of permanent adaptation, that is, traditional banking versus new types of business processes. Therefore, it is important to find out how it may be affecting the sector;
- ✓ Labour vs machinery substitution battle – as stated by Dionísio, Gonçalves & Sampaio (2018), labour flexibility in human resources management continues to be the subject of various studies due to the competitive and dynamic context of the contemporary business environment which force organizations to find new ways namely, new operational strategies and structural changes. Moreover, social security issues (Holzmann, Ayuso, & Bravo, 2019) must be taken into account.

In conclusion, this research can be a starting point to the study of productivity and efficiency using DEA method in the Mozambican economy.

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7. ANNEXES

7.1. RESULTS FROM DEAP VERSION 2.1

Results from DEAP Version 2.1 (2008 – 2010)

```
Instruction file = MZ1-ins.txt
Data file        = MZ1-dta.txt

 Output orientated Malmquist DEA


 DISTANCES SUMMARY


 year =     1

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
               t-1         t        t+1

     1     0.000     1.000     1.119     1.000
     2     0.000     0.916     0.851     0.981
     3     0.000     0.588     0.655     0.589
     4     0.000     1.000     1.021     1.000
     5     0.000     0.735     0.791     1.000
     6     0.000     0.701     0.765     1.000
     7     0.000     0.940     1.098     1.000
     8     0.000     0.432     0.401     0.435
     9     0.000     0.888     0.809     0.897
    10     0.000     0.485     0.529     1.000
    11     0.000     1.000     1.082     1.000
    12     0.000     1.000     1.612     1.000

 mean      0.000     0.807     0.894     0.909

 year =     2

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
               t-1         t        t+1

     1     1.239     1.000     1.152     1.000
     2     1.111     0.919     1.030     0.935
     3     0.689     0.749     0.679     0.764
     4     0.972     0.991     1.011     1.000
     5     0.647     0.659     0.669     0.702
     6     0.615     0.636     0.584     1.000
     7     0.507     0.517     0.500     0.899
     8     0.527     0.498     0.525     0.510
     9     0.736     0.721     0.749     0.739
    10     0.582     0.540     0.572     1.000
    11     1.164     1.000     1.120     1.000
    12     0.878     1.000     1.353     1.000

 mean      0.806     0.769     0.829     0.879
```

year = 3

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	1.111	1.000	0.000	1.000
2	0.875	1.000	0.000	1.000
3	0.696	0.634	0.000	0.649
4	0.982	1.000	0.000	1.000
5	0.600	0.608	0.000	0.627
6	0.720	0.661	0.000	1.000
7	0.618	0.595	0.000	1.000
8	0.456	0.482	0.000	0.493
9	0.661	0.691	0.000	0.710
10	0.534	0.551	0.000	1.000
11	1.085	1.000	0.000	1.000
12	0.899	1.000	0.000	1.000
mean	0.770	0.769	0.000	0.873

[Note that t-1 in year 1 and t+1 in the final year are not defined]

MALMQUIST INDEX SUMMARY

year = 2

firm	effch	techch	pech	sech	tfpch
1	1.000	1.052	1.000	1.000	1.052
2	1.002	1.142	0.952	1.052	1.144
3	1.273	0.909	1.296	0.983	1.157
4	0.991	0.980	1.000	0.991	0.971
5	0.896	0.955	0.702	1.278	0.856
6	0.907	0.941	1.000	0.907	0.854
7	0.550	0.916	0.899	0.612	0.504
8	1.155	1.067	1.171	0.986	1.232
9	0.811	1.059	0.825	0.984	0.859
10	1.113	0.994	1.000	1.113	1.107
11	1.000	1.037	1.000	1.000	1.037
12	1.000	0.738	1.000	1.000	0.738
mean	0.957	0.977	0.977	0.980	0.935

year = 3

firm	effch	techch	pech	sech	tfpch
1	1.000	0.982	1.000	1.000	0.982
2	1.089	0.884	1.070	1.018	0.962
3	0.847	1.100	0.849	0.997	0.932
4	1.010	0.981	1.000	1.010	0.990
5	0.923	0.985	0.894	1.032	0.909
6	1.040	1.089	1.000	1.040	1.132
7	1.150	1.036	1.112	1.034	1.192
8	0.968	0.947	0.966	1.002	0.917
9	0.959	0.959	0.961	0.998	0.920
10	1.021	0.956	1.000	1.021	0.976
11	1.000	0.984	1.000	1.000	0.984
12	1.000	0.815	1.000	1.000	0.815
mean	0.998	0.974	0.986	1.013	0.971

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

year	effch	techch	pech	sech	tfpch
2	0.957	0.977	0.977	0.980	0.935
3	0.998	0.974	0.986	1.013	0.971
mean	0.977	0.975	0.981	0.996	0.953

MALMQUIST INDEX SUMMARY OF FIRM MEANS

firm	effch	techch	pech	sech	tfpch
1	1.000	1.017	1.000	1.000	1.017
2	1.045	1.004	1.009	1.035	1.049
3	1.038	1.000	1.049	0.990	1.038
4	1.000	0.981	1.000	1.000	0.981
5	0.910	0.970	0.792	1.148	0.882
6	0.972	1.012	1.000	0.972	0.983
7	0.796	0.974	1.000	0.796	0.775
8	1.057	1.005	1.064	0.994	1.063
9	0.882	1.008	0.890	0.991	0.889
10	1.066	0.975	1.000	1.066	1.039
11	1.000	1.010	1.000	1.000	1.010
12	1.000	0.776	1.000	1.000	0.776
mean	0.977	0.975	0.981	0.996	0.953

[Note that all Malmquist index averages are geometric means]

Results from DEAP Version 2.1 (2011 - 2013)

Instruction file = MZ2-ins.txt
Data file = MZ2-dta.txt

Output orientated Malmquist DEA

DISTANCES SUMMARY

year = 1

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.000	1.000	0.747	1.000
2	0.000	0.600	0.635	0.847
3	0.000	0.552	0.287	0.553
4	0.000	0.753	0.497	0.966
5	0.000	0.501	0.319	0.601
6	0.000	0.829	0.319	1.000
7	0.000	0.651	0.423	0.734
8	0.000	0.697	0.390	0.731
9	0.000	0.453	0.274	0.535
10	0.000	0.484	0.323	0.502
11	0.000	0.547	0.289	0.664
12	0.000	1.000	0.469	1.000
13	0.000	1.000	0.854	1.000
14	0.000	1.000	1.185	1.000
mean	0.000	0.719	0.501	0.795

year = 2

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.744	0.768	0.932	1.000
2	0.516	0.610	0.688	0.792
3	0.655	0.588	0.767	0.873
4	0.648	0.442	0.562	0.820
5	0.404	0.316	0.441	0.462
6	0.842	0.374	0.320	0.830
7	0.613	0.418	0.538	0.715
8	0.575	0.389	0.570	0.660
9	0.408	0.224	0.192	0.248
10	0.481	0.321	0.270	0.338
11	0.446	0.219	0.184	0.222
12	1.183	0.493	0.447	0.523
13	1.657	1.000	1.084	1.000
14	5.376	1.000	2.281	1.000
mean	1.039	0.511	0.662	0.677

year = 3

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.887	1.000	0.000	1.000
2	0.601	0.694	0.000	0.705
3	0.560	0.782	0.000	0.942
4	0.494	0.573	0.000	0.871
5	0.415	0.550	0.000	0.654
6	0.356	0.396	0.000	0.563
7	0.447	0.635	0.000	0.712
8	0.565	0.738	0.000	0.756
9	0.375	0.314	0.000	0.341
10	0.326	0.273	0.000	0.293
11	0.203	0.187	0.000	1.000
12	0.528	0.470	0.000	0.604
13	0.255	0.235	0.000	1.000
14	1.209	1.000	0.000	1.000
mean	0.516	0.561	0.000	0.746

[Note that t-1 in year 1 and t+1 in the final year are not defined]

MALMQUIST INDEX SUMMARY

year = 2

firm	effch	techch	pech	sech	tfpch
1	0.768	1.139	1.000	0.768	0.875
2	1.016	0.895	0.936	1.085	0.909
3	1.065	1.463	1.580	0.674	1.558
4	0.587	1.490	0.849	0.691	0.874
5	0.632	1.417	0.770	0.820	0.895
6	0.452	2.416	0.830	0.544	1.091
7	0.642	1.502	0.975	0.658	0.964
8	0.558	1.627	0.903	0.618	0.907
9	0.493	1.736	0.462	1.067	0.856
10	0.662	1.499	0.673	0.983	0.993
11	0.401	1.963	0.334	1.199	0.787
12	0.493	2.261	0.523	0.943	1.115
13	1.000	1.393	1.000	1.000	1.393
14	1.000	2.130	1.000	1.000	2.130
mean	0.664	1.586	0.792	0.838	1.052

year = 3

firm	effch	techch	pech	sech	tfpch
1	1.303	0.855	1.000	1.303	1.113
2	1.138	0.876	0.889	1.280	0.997
3	1.331	0.741	1.079	1.234	0.986
4	1.296	0.823	1.062	1.220	1.067
5	1.739	0.736	1.413	1.230	1.280
6	1.058	1.026	0.678	1.560	1.086
7	1.520	0.739	0.995	1.528	1.123
8	1.900	0.723	1.146	1.658	1.373
9	1.403	1.181	1.378	1.018	1.657
10	0.850	1.191	0.867	0.980	1.012
11	0.852	1.138	4.509	0.189	0.970
12	0.953	1.114	1.155	0.826	1.062
13	0.235	1.000	1.000	0.235	0.235
14	1.000	0.728	1.000	1.000	0.728
mean	1.084	0.903	1.148	0.944	0.979

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

year	effch	techch	pech	sech	tfpch
2	0.664	1.586	0.792	0.838	1.052
3	1.084	0.903	1.148	0.944	0.979
mean	0.848	1.197	0.954	0.889	1.015

MALMQUIST INDEX SUMMARY OF FIRM MEANS

firm	effch	techch	pech	sech	tfpch
1	1.000	0.987	1.000	1.000	0.987
2	1.075	0.885	0.912	1.179	0.952
3	1.191	1.041	1.306	0.912	1.239
4	0.872	1.107	0.950	0.919	0.966
5	1.048	1.021	1.043	1.005	1.070
6	0.691	1.575	0.750	0.921	1.089
7	0.988	1.053	0.985	1.003	1.040
8	1.029	1.084	1.017	1.012	1.116
9	0.832	1.432	0.798	1.042	1.191
10	0.750	1.336	0.764	0.982	1.002
11	0.584	1.494	1.228	0.476	0.873
12	0.686	1.587	0.777	0.883	1.088
13	0.485	1.180	1.000	0.485	0.573
14	1.000	1.245	1.000	1.000	1.245
mean	0.848	1.197	0.954	0.889	1.015

[Note that all Malmquist index averages are geometric means]

Results from DEAP Version 2.1 (2014 - 2018)

Instruction file = MZ3-ins.txt
Data file = MZ3-dta.txt

Output orientated Malmquist DEA

DISTANCES SUMMARY

year = 1

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.000	0.683	0.978	1.000
2	0.000	0.499	0.680	0.761
3	0.000	0.495	0.574	0.914
4	0.000	0.580	0.666	1.000
5	0.000	0.375	0.425	0.644
6	0.000	0.296	0.332	0.549
7	0.000	1.000	5.107	1.000
8	0.000	0.504	0.638	0.722
9	0.000	0.230	0.212	0.265
10	0.000	0.644	0.447	1.000
11	0.000	0.130	0.119	0.130
12	0.000	0.148	0.160	0.180
13	0.000	0.466	0.586	0.476
14	0.000	0.149	0.155	0.154
15	0.000	0.827	1.023	0.844
16	0.000	1.000	2.068	1.000
mean	0.000	0.502	0.886	0.665

year = 2

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.576	0.870	0.899	1.000
2	0.460	0.606	0.626	0.885
3	0.544	0.633	0.630	1.000
4	0.332	0.372	0.311	0.968
5	0.418	0.479	0.444	0.704
6	0.365	0.467	0.437	0.583
7	0.388	0.452	0.454	0.641
8	0.451	0.564	0.583	0.772
9	0.255	0.207	0.161	0.268
10	0.192	0.214	0.171	1.000
11	0.142	0.154	0.121	0.171
12	0.203	0.224	0.177	0.339
13	0.462	0.577	0.478	0.659
14	0.410	0.284	0.258	1.000
15	0.854	1.000	1.034	1.000
16	1.441	1.000	0.908	1.000
mean	0.468	0.506	0.481	0.749

year = 3

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.954	0.905	0.977	1.000
2	0.614	0.635	0.699	0.919
3	0.594	0.607	0.683	1.000
4	0.566	0.392	0.458	1.000
5	0.405	0.288	0.335	0.643
6	0.441	0.305	0.357	0.691
7	0.704	0.500	0.582	0.875
8	0.480	0.496	0.553	0.702
9	0.321	0.240	0.372	0.365
10	0.258	0.205	0.243	1.000
11	0.396	0.365	0.420	0.366
12	0.249	0.172	0.201	0.194
13	0.628	0.546	0.830	0.556
14	0.510	0.463	0.718	1.000
15	0.799	0.655	0.765	0.683
16	1.444	1.000	1.551	1.000
mean	0.585	0.486	0.609	0.750

year = 4

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.926	1.000	0.853	1.000
2	0.468	0.519	0.431	0.685
3	0.497	0.581	0.443	1.000
4	0.473	0.553	0.411	1.000
5	0.327	0.382	0.259	0.597
6	0.359	0.421	0.351	0.667
7	0.534	0.601	0.492	0.710
8	0.556	0.640	0.512	0.985
9	0.187	0.221	0.230	0.293
10	0.236	0.280	0.328	0.676
11	0.325	0.375	0.299	0.512
12	0.242	0.283	0.228	0.483
13	0.517	0.786	0.884	0.841
14	0.498	0.758	0.852	1.000
15	0.623	0.728	0.736	0.741
16	0.856	1.000	1.322	1.000
mean	0.477	0.570	0.539	0.762

year = 5

firm no.	crs te rel to tech in yr t-1	t	t+1	vrs te
1	0.951	0.772	0.000	1.000
2	0.502	0.371	0.000	0.737
3	0.537	0.409	0.000	1.000
4	0.461	0.304	0.000	0.839
5	0.302	0.250	0.000	0.574
6	0.355	0.322	0.000	0.604
7	0.628	0.515	0.000	0.778
8	0.715	0.579	0.000	1.000
9	0.245	0.197	0.000	0.299
10	0.338	0.222	0.000	1.000
11	0.518	0.430	0.000	1.000
12	0.287	0.229	0.000	0.231
13	0.819	0.921	0.000	1.000
14	0.630	0.582	0.000	1.000
15	0.792	0.741	0.000	0.746
16	1.522	1.000	0.000	1.000
mean	0.600	0.490	0.000	0.800

[Note that t-1 in year 1 and t+1 in the final year are not defined]

MALMQUIST INDEX SUMMARY

year = 2

firm	effch	techch	pech	sech	tfpch
1	1.274	0.680	1.000	1.274	0.866
2	1.213	0.747	1.163	1.042	0.906
3	1.277	0.861	1.094	1.167	1.100
4	0.642	0.881	0.968	0.663	0.566
5	1.279	0.876	1.093	1.170	1.121
6	1.579	0.835	1.062	1.487	1.318
7	0.452	0.410	0.641	0.705	0.185
8	1.119	0.795	1.068	1.047	0.889
9	0.899	1.158	1.010	0.890	1.041
10	0.332	1.139	1.000	0.332	0.378
11	1.183	1.006	1.312	0.902	1.190
12	1.512	0.916	1.879	0.804	1.385
13	1.239	0.798	1.383	0.895	0.989
14	1.914	1.176	6.498	0.295	2.251
15	1.209	0.831	1.185	1.020	1.005
16	1.000	0.835	1.000	1.000	0.835
mean	1.043	0.849	1.226	0.851	0.886

year = 3

firm	effch	techch	pech	sech	tfpch
1	1.040	1.010	1.000	1.040	1.050
2	1.048	0.967	1.039	1.009	1.014
3	0.960	0.992	1.000	0.960	0.952
4	1.052	1.315	1.033	1.019	1.384
5	0.601	1.231	0.913	0.658	0.739
6	0.653	1.242	1.186	0.551	0.811
7	1.107	1.185	1.365	0.811	1.311
8	0.879	0.967	0.910	0.967	0.851
9	1.157	1.313	1.362	0.850	1.520
10	0.960	1.256	1.000	0.960	1.205
11	2.375	1.176	2.136	1.112	2.793
12	0.767	1.353	0.571	1.342	1.038
13	0.945	1.178	0.843	1.121	1.114
14	1.628	1.101	1.000	1.628	1.793
15	0.655	1.086	0.683	0.960	0.712
16	1.000	1.261	1.000	1.000	1.261
mean	0.990	1.158	1.020	0.971	1.147

year = 4

firm	effch	techch	pech	sech	tfpch
1	1.105	0.926	1.000	1.105	1.023
2	0.818	0.905	0.745	1.098	0.740
3	0.957	0.872	1.000	0.957	0.835
4	1.411	0.856	1.000	1.411	1.207
5	1.327	0.858	0.928	1.430	1.139
6	1.379	0.854	0.966	1.428	1.177
7	1.201	0.875	0.812	1.479	1.051
8	1.291	0.883	1.403	0.920	1.140
9	0.920	0.739	0.803	1.145	0.680
10	1.363	0.843	0.676	2.016	1.149
11	1.028	0.867	1.399	0.734	0.891
12	1.643	0.856	2.495	0.658	1.405
13	1.441	0.657	1.513	0.952	0.947
14	1.638	0.651	1.000	1.638	1.066
15	1.112	0.856	1.085	1.024	0.951
16	1.000	0.743	1.000	1.000	0.743
mean	1.203	0.823	1.055	1.140	0.990

year = 5

firm	effch	techch	pech	sech	tfpch
1	0.772	1.202	1.000	0.772	0.928
2	0.715	1.276	1.076	0.664	0.912
3	0.704	1.312	1.000	0.704	0.923
4	0.549	1.430	0.839	0.654	0.785
5	0.654	1.337	0.961	0.681	0.874
6	0.765	1.150	0.905	0.845	0.880
7	0.857	1.220	1.095	0.783	1.046
8	0.904	1.242	1.015	0.891	1.123
9	0.894	1.091	1.020	0.877	0.976
10	0.794	1.140	1.479	0.537	0.905
11	1.144	1.231	1.953	0.586	1.408
12	0.809	1.248	0.478	1.694	1.010
13	1.171	0.890	1.189	0.985	1.042
14	0.769	0.981	1.000	0.769	0.754
15	1.018	1.028	1.007	1.011	1.047
16	1.000	1.073	1.000	1.000	1.073
mean	0.829	1.170	1.024	0.809	0.970

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

year	effch	techch	pech	sech	tfpch
2	1.043	0.849	1.226	0.851	0.886
3	0.990	1.158	1.020	0.971	1.147
4	1.203	0.823	1.055	1.140	0.990
5	0.829	1.170	1.024	0.809	0.970
mean	1.008	0.986	1.078	0.934	0.994

MALMQUIST INDEX SUMMARY OF FIRM MEANS

firm	effch	techch	pech	sech	tfpch
1	1.031	0.935	1.000	1.031	0.964
2	0.928	0.956	0.992	0.936	0.887
3	0.953	0.994	1.023	0.932	0.948
4	0.851	1.091	0.957	0.889	0.928
5	0.904	1.055	0.971	0.930	0.953
6	1.021	1.004	1.024	0.997	1.026
7	0.847	0.849	0.939	0.902	0.719
8	1.035	0.958	1.085	0.954	0.992
9	0.962	1.052	1.030	0.933	1.012
10	0.766	1.083	1.000	0.766	0.829
11	1.348	1.060	1.664	0.810	1.429
12	1.114	1.073	1.064	1.048	1.195
13	1.186	0.861	1.204	0.985	1.021
14	1.407	0.954	1.597	0.881	1.342
15	0.973	0.944	0.970	1.003	0.919
16	1.000	0.957	1.000	1.000	0.957
mean	1.008	0.986	1.078	0.934	0.994

[Note that all Malmquist index averages are geometric means]

7.2. LINEAR REGRESSION MODEL OUTPUT

```
Call:
lm(formula = TFPCh ~ Emp + KLev + Imp + IR + ROE + ROA + TA +
    GDP, data = data2)

Residuals:
     Min       1Q   Median       3Q      Max
-2.58624 -0.71662 -0.05051 0.75249 2.57176

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.72781    0.66262   2.608 0.009945 **
Emp         -0.39394    0.10539  -3.738 0.000254 ***
KLev        -0.66113    0.19644  -3.365 0.000948 ***
Imp          0.38647    0.21223   1.821 0.070393 .
IR          -0.34827    0.10705  -3.253 0.001381 **
ROE         -0.41462    0.15148  -2.737 0.006869 **
ROA          0.50279    0.17424   2.886 0.004423 **
TA           0.25567    0.04888   5.231    5e-07 ***
GDP         -0.86196    0.30417  -2.834 0.005167 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.152 on 167 degrees of freedom
Multiple R-squared:  0.3353,Adjusted R-squared:  0.3035
F-statistic: 10.53 on 8 and 167 DF, p-value: 6.521e-12
```