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The productivity growth of Malaysian microfinance institutions: Implications for consumer, sustainable business and economic growth

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ABSTRACT

Microfinance Institutions [MFIs] from 2009 to 2020, exploring implications for consumers, sustainable business, and economic growth. The Data Envelopment Analysis-Malmquist Productivity Index (DEA-MPI) is used to evaluate productivity growth, which incorporates three total inputs: branches, total staff, and total subsidies, and a single output: the total number of borrowers. The mean total factor productivity regression among Malaysian MFIs was 8.3%, primarily attributable to a technological regression of 13.4%. Technical efficiency improved modestly by 5.9%, with notable scale efficiency gains observed in 2010, remaining essentially stable thereafter. Pure technical efficiency is indicated by the lack of notable increases, underscoring managerial stagnation. Malaysian MFIs must strategically enhance their technological capabilities, despite stable scale efficiency and productivity declines, largely resulting from inadequate adoption of new technology and a lack of innovation. By providing incentives, training courses, and strategic alliances, policymakers should prioritize technological innovation and digital transformation. These measures will optimize MFI operations, improve service delivery to underserved markets, and align MFIs with Malaysia's broader socioeconomic development objectives.

Contribution/ Originality: This study uniquely employs a novel approach to analyze technology and efficiency disparities within Malaysian MFIs from 2009 to 2020 using the DEA-Malmquist Productivity Index. By revealing targeted insights into the causes of their productivity decline, especially technological regression, it highlights key areas for policy intervention aimed at sustainable economic growth.

1. INTRODUCTION

In the past decades, particularly in developing nations, microfinance institutions (MFIs) have contributed significantly to financial inclusion as well as socioeconomic development. The level of efficiency in MFIs has received increased attention in recent years, as financial inclusion is a necessary step to alleviate socioeconomic issues and reduce poverty (Mishra, Rathore, Pandey, Singh, & Katiyar, 2024). The microfinance sector, which provides financial services to the poor and underprivileged, can improve their lives and the community's well-being. Over 100 million people have benefited from financial services through the emergence of MFIs, which can increase living standards and help eliminate poverty (Liñares-Zegarra & Wilson, 2018). Furthermore, Islamic finance principles in microfinance have been a part of microfinance since time immemorial; Islamic finance principles have also experienced

their unique challenges as well as opportunities. The Islamic microfinance loans designed to accommodate business lending requirements are crucial to customer satisfaction as well as the sustainability of the microfinance institution (Afoukane, Utami, & Nugroho, 2021). The measurement of microfinance, however, has also received much attention in recent years. Indeed, productivity measurement is not an academic exercise but a requirement since productivity measurement involves the livelihoods of millions of people.

In Malaysia, MFIs have been contributing significantly to the underprivileged community by promoting entrepreneurship and reducing inequality. MFIs actively contribute to economic inclusivity and sustainability, which are crucial elements for increasing the well-being and economic development of underprivileged people in Malaysia, in line with Malaysia's development vision (Jalil, 2021). Besides, the efficiency of MFIs in meeting these objectives largely relates to productivity; if MFIs can serve effectively, then they can make efficient use of limited resources to make a difference to customers, families, as well as to small business proprietors. Productivity can be viewed from a variety of different perspectives, including the ability of MFIs to make efficient use of resources and expand services. Bandiera et al. (2022) suggest that microfinance programs have great potential in reaching poor families and facilitating productive investment that can increase non-subsistence activities to drive individuals out of poverty. MFI's role also involves lending credit, which is a crucial component in increasing economic resilience. Additionally, Kar and Rahman (2018) also welcome the change in total factor productivity and efficiency to assess the sustainable long-run success of MFIs in developing countries. Hence, MFI's productivity is highly critical, as productivity can determine MFI's success in developing countries.

Although the success of MFI's role in developing socioeconomic conditions has been widely studied, MFI's productivity performance in Malaysia is disappointingly low in terms of dimension. Lwesya and Mwakalobo (2023) draw attention to more research in terms of productivity indicators, as well as MFI's operational efficiency, especially in developing context such as Malaysia, since the research have shown that the MFI's in Malaysia have relatively less studies in terms of productivity level. Hence, the productivity space is relatively unexplored; therefore, there is a need for studies that assess MFI's impact, as well as critically evaluate their operational efficiencies and productivity indicators (Abdullah, Zainudin, Ismail, & Zia-Ul-Haq, 2022; Loke, Adebola, Ramasamy, & Dahalan, 2020). It also recommends further research to identify and understand the impact of productivity levels on the efficiency of microfinance services, particularly among vulnerable populations in Malaysia. This becomes critical in addressing productivity dynamics, including technological and efficiency variations over time, to enhance the operational efficiency of MFIs in line with Malaysia's developmental priorities.

The productivity levels of MFIs require research into their efficiency to determine how effectively they can achieve their objectives. The importance of measuring productivity levels in MFIs cannot be overstated, especially in Malaysia, where growth in the microfinance sector has been significant over the past two decades. Most MFIs utilize DEA and MPI methods to assess their efficiency and productivity. The DEA methodology and Malmquist Productivity Index can be applied to evaluate efficiency and productivity changes over time for various types of microfinance institutions. These tools provide a robust framework for assessing efficiency and productivity variations over time, helping MFIs optimize operations and enhance service delivery. The DEA-Malmquist index can be used in various sectors, such as health and agriculture. For instance, in this context, Zhou et al. (2023) used DEA-Malmquist method in comparing efficiency in China's primary health centers, noting its wide range of applications in gauging productivity of different forms of non-profit organizations. Likewise, Chaubey, Sharanappa, Mohanta, Mishra, and Mishra (2022) used the Malmquist DEA method in comparing the productivity of India's agricultural sector, further establishing a wide range of applications of the methodology in different areas. It's notable that DEA-Malmquist index usage was also extended to educational establishments, as underscored in the research by Yousaf and Chani on TEVETA Institute's cost efficiency and productivity in Punjab, Pakistan.

The research in question, therefore, emphasizes productivity measurement in education non-profits as crucial, shedding light on potential applications in microfinance organizations as well. It is also notable that such instruments

can offer a method of assessing efficiency as well as productivity change over time, supporting MFIs to optimize their activities as well as improve the delivery of services. The DEA-Malmquist productivity index is a multi-dimensional index since it can evaluate a few inputs as well as outputs simultaneously. Another feature of the Malmquist index involves its ability to break down changes in productivity over time (Kar & Bali Swain, 2018, 2024). The DEA-Malmquist productivity index, however, can be tailored to adapt to the unique aspects of microfinance markets as well as to include both financial as well as non-financial variables to give an all-round assessment of MFIs (Ghising, 2022; Shu-Teng, Zariyawati, Suraya-Hanim, & Annuar, 2015). For instance, in Malaysia, where specific regulations exist in terms of institutional regulation, as well as a given cultural context, DEA methodology can therefore be tailored to measure performance effectively. Shu-Teng et al. (2015) depict diverse forms of MFIs in Malaysia, such as credit unions, cooperatives, as well as NGOs, underscoring a requirement for a responsive method of performance measurement.

In light of identified gaps in research and the overarching significance of MFI productivity in meeting sustainable development targets, this research aims to assess productivity growth in Malaysian MFIs from 2009 to 2020. By utilizing the MPI, this study seeks to decompose changes in productivity into efficiency gains and technological change, providing valuable insights into MFI operational dynamics. The findings have the potential to inform policymakers and practitioners, guiding strategic interventions to enhance MFIs and align them with broader development objectives in Malaysia.

This research provides useful contributions to policymakers as well as practitioners in Malaysia by drawing key lessons from Microfinance Institutions (MFIs) productivity as well as sustainability. It highlights the importance of putting in place strong financial systems as well as support systems to fortify MFI operational strength. Additionally, the research draws attention to designing appropriate borrower engagement strategies, given that satisfaction from borrowers ranks among key determinants of success for MFIs. By aligning MFI operations strategically with national sustainability aims and integrating principles of good governance, borrower-centric strategies, as well as environmental sensitivity, this research offers a roadmap for MFI enhancement towards increasing economic inclusiveness and pursuing Malaysia's sustainability development targets. The rationale for these findings is to help maximize MFI socio-economic contributions to the broader economic landscape of the country. The rest of the paper is organized as follows: Section 2 discusses the literature and theoretical background. Section 3 outlines the methodological framework, including the Malmquist productivity index. Section 4 presents the analysis of findings. Section 5 addresses policy implications and provides recommendations for future research. Section 6 concludes the paper.

2. LITERATURE REVIEW

Malaysia contributed significantly to the delivery of financial services to underprivileged groups, in its efforts to reduce poverty, promote economic development, and support micro-enterprises. This crystallized the mission of Malaysia's microfinance to encompass low-income, low-net-worth, underprivileged populations, and individuals who lack access to formal financial services (Abdullah et al., 2022; Duasa & Zainal, 2020). From 1987, Malaysia set up Malaysia's first microfinance institution (MFI) in the form of Amanah Ikhtiar Malaysia (AIM) to conduct financial services to the underprivileged individuals which have been excluded by the formal banking system (Abdullah et al., 2022; Redzuan & Bashir, 2021). AIM performs a crucial function in promoting access to microcredit that stimulates entrepreneurship among low-income groups as well as boosting their incomes (Abdullah et al., 2022; Al Mamun, Muniady, Fazal, & Malarvizhi, 2019). Besides AIM, other organizations have emerged as well, such as the establishment of Yayasan Usaha Maju (YUM) in 1995 and Tabung Ekonomi Kumpulan Usaha Niaga (TEKUN) in 1998. Both aim to fund diverse populations and initiate distinct lending mechanisms to improve financial accessibility. YUM extends microcredit facilities and support services to poor people in the Sabah state to help them learn skills for entrepreneurship, which can lead to their economic development. TEKUN provides financing to small

entrepreneurs in Malaysia, targeting both male and female entrepreneurs. It also offers more flexibility in terms of duration, such as the grace period, for conducting various business activities.

Microfinance services contribute positively to clients' financial and economic well-being, as evidenced by improved living standards and increased household incomes (Abdullah, Zainudin, & Muhammad Zia-ul-haq, 2024; Solarin, Loke, Ramasamy, Yen, & Gan, 2022). Microfinance membership can, for instance, increase employment opportunities as well as productive assets that can drive the earning potential of fund recipients to reduce poverty in each country (Al Mamun et al., 2019; Solarin et al., 2022). Microfinance services, such as offering training and social intermediaries, can improve the socioeconomic welfare of urban poor families, especially those from economically disadvantaged regions like Sabah (Koh, Solarin, Yuen, Ramasamy, & Goh, 2021; Solarin et al., 2022).

In spite of the advantages of microfinance, Malaysia's microfinance industry encounters many challenges. Some of these involve high non-performing loans (NPLs), which can increase the cost of microfinance and negatively impact microfinance programs (Hassan, Yahya, & Shari, 2023; Shu-Teng et al., 2015). High NPLs of MFIs can drive the needy away from MFI's social mission (Hassan et al., 2023). Another issue involves the constant monitoring of the effect of microfinance on increasing the productivity of microenterprises. The research conducted to determine the effectiveness of microfinance in increasing productivity has yielded mixed findings (Abdullah et al., 2024; Nor & Rosli, 2021). Although research indicated that microfinance improved the performance of micro-enterprises, efficiency in microfinance is subject to a few factors, including credibility (Nor & Rosli, 2021).

Therefore, to ensure that microfinance institutions (MFIs) achieve their dual objectives of generating social impact and ensuring financial sustainability, it is important to measure their productivity. Increasing the productivity of MFIs would improve their efficiency, enabling them to serve more clients and ultimately contribute to eradicating poverty and promoting economic growth. There are various methods to measure the productivity of MFIs; however, the Malmquist Productivity Index (MPI) is the most widely used approach (Ambarkhane, Singh, & Venkataramani, 2019). The primary reason for MPI's popularity is that MPI can be used to examine changes in productivity over time intervals, considering changes in technical efficiency as well as technological advancement. MPI is a chained index that can make comparisons between consecutive intervals; hence, it responds to small variations in productivity (Ambarkhane et al., 2019). This is crucial for MFIs as it allows productivity trends to be monitored and decisions to be made after considering finer details. Moreover, MPI can be broken down into three components: the technology change index, the technical efficiency change (TEC) index, and the scale efficiency change index (Ambarkhane et al., 2019). This breakdown can enable in-depth analysis of drivers of productivity change, which in turn can help identify areas for improvement.

Empirical research has proved MPI's efficiency in assessing MFI productivity. For example, Rana, Banna, Mia, Ismail, and Ismail (2022) used MPI to evaluate the productivity of 26 MFIs in Bangladesh, which was found to have ranged from a low of 0.9 to a high of 1.20 over a period from 2009 to 2018 (Rana et al., 2022). The above research depicts MPI's potential to gauge not only the social productivity but also the financial productivity of MFIs, thereby providing a comprehensive view of their performance.

MPI is used to gauge productivity in MFIs at a global level. For instance, in Efendić and Hadžiahmetović (2019) they examined changes in productivity in Bosnia and Herzegovina's MFIs from 2008 to 2015 and noted dramatic changes in total factor productivity (TFP) in and after the financial crisis. The research found that productivity changes can occur significantly in an MFI as a result of external economic factors, necessitating adaptability and robustness in its operations (Efendić & Hadžiahmetović, 2019). Likewise, in Kar and Rahman (2018) they conducted a thorough analysis of MFIs in the developing world employing a non-parametric method to gauge productivity. Their research highlights technological developments as well as operational effectiveness in increasing productivity levels across different regions.

In ASEAN countries, MFI productivity can differ because of variations in both economic conditions in each place as well as institutional structures. For instance, it was reported by Khan and Gulati (2021) that NBFC MFIs

performed better than non-NBFC MFIs, with smaller MFIs experiencing a high growth in TFP (Khan & Gulati, 2021). This means that organizational size, as well as structural aspects, matter as drivers in influencing productivity. Productive as well as organizational efficiency in Indian MFIs are essential to ensure better financial inclusion of poor rural dwellers, according to research by Muneer Babu and Kulshreshtha (2014).

The MENA region also sheds light on the productivity dynamics of MFIs. Bassem (2014) used the Malmquist productivity index to investigate TFP growth of MFIs in the MENA region and revealed that technology gains were the most significant driver of productivity growth. This indicates that technological adoption to improve efficiency was crucial. The adoption of technology also helps organizations improve productivity. Wijesiri and Meoli (2015) employed a bootstrap Malmquist to investigate productivity change in MFIs and discovered that MFIs that advance technology strengthen their ability to enhance productivity measures. Lastly, apart from MFIs, productivity also draws from evidence from other elements, such as the manufacturing sector. Han (2022) worked in the context of China's manufacturing sector to find that structural transformation and technological advance played a key role in inducing TFP growth. The findings indicate that the simplification process could aid in increasing efficiency in resource allocation as well as stimulating productivity growth. This is crucial for ASEAN countries, given that bureaucracy continues to impact productivity growth. The productivity of China's forest resources also provides evidence from which the new productivity measure draws to promote growth in TFP. The new measure employed in this research utilized two methods, namely DEA-SBM and meta-frontier. The findings reflect that technological heterogeneity and growth of TFP for entities with higher efficiency gains approach the national frontier and could be used to further assess the productivity gap. This research suggests a potential rise in productivity in resource-intensive industries crucial to ASEAN countries as they work toward achieving a sustainable economy and living off natural resources (Shah, Hao, Yan, Shen, & Yasmeen, 2024).

Phuong (2018) applied the Malmquist productivity index to examine Vietnamese coal mining using a decomposition of total factor productivity (TFP) growth into technical change and efficiency change. It was found that technological change contributed more to TFP growth than efficiency change. This suggests the importance of identifying sources of technological growth and their contribution to productivity growth. It also provides a foundation for future policies aimed at increasing industrial efficiency in coal mining. Empirical research on MFIs has significantly contributed to understanding productivity and the dynamics of work within MFIs. However, some gaps in research still exist, such as critical insights into methodology, regional dynamics, and key findings influencing the sector. For Malaysia, research on productivity performance will help bridge the gap by serving as an index in international literature, allowing comparisons with the productivity performance of other MFIs regionally and methodologically. Therefore, it is relevant to discuss the productivity performance of MFIs, as well as customer benefits, business sustainability, and growth.

3. METHODOLOGY

3.1. Data and Variables Selection

The methodologies employed in the analysis of the productivity growth of microfinance institutions (MFIs) in Malaysia are presented in this section. Secondary data was collected over a period of 12 years, from 2009 to 2020, for this study. Since there was no data available for some of the MFIs before 2021, the study considered data provided by the sample up to, but not including, 2021. Only current MFIs in Malaysia are included in this study. Secondary data for all variables were collected during the study period from MFIs' annual reports based in Malaysia, the annual report of the Central Bank of Malaysia, and the state audit reports for each year. Secondary data refers to information collected from already published sources, such as company reports, websites, financial statements, and government publications (Sekaran & Bougie, 2013).

One of the decision-making units of MFIs in Malaysia, which is AIM, was formed 11 years after TEKUN, which was established in 1998, in this study. It is not until 2009 that the TEKUN data were made available to the public,

while TEKUN itself was established in 1998. Despite the chronological matching, anomalies and lack of reporting from MFIs in Malaysia have generated discrepancies in data availability between 2009 and 2020. The data set extending this period needs to be carefully measured as it presents differences in the formats and types of data to be handled, to be included in the DEA-Malmquist index measurement model. This research divides the data into inputs (the number of total branches, employed personnel, and government subsidies) and outputs (the number of total borrowers). The number of output and input variables in this research meets the criteria recommended by Banker, Charnes, and Cooper (1984) which requires n ≥ max {input * output, 3(input + output)}, and those due to Dyson et al. (2001) which claims n ≥ 2 * (inputs + outputs), and Brown (2006) which insists n ≥ 3 * (inputs + outputs). This justifies the study's choice of volatility as the measure of efficiency in the case of the Malaysian MFIs.

The three-input, one-output models are built on the review of the DEA applications and the Malmquist index. The selected input is total branches, staff, and subsidy, and the output is the total number of borrowers. The number of borrowers emanating in the output (Table 1) varied a lot; it ranged from 247,000 to 421,000, with an average of 350,000 borrowers over the study period. Over the years of the study, the number of MFI branches varied from 280 to 318 and averaged nearly 304 branches. The number of staff members of MFIs in Malaysia has been increasing over the 12 years of the study. Based on only 2,000 employees to a high of 3,000, the average was approximately 3,000. The signal of a strengthened effort in the sector to enlarge microfinance services, especially for the extension of financial access to underprivileged people (Mokhtar, 2011), may be read. The current study also investigates the total amount of subsidy received by Malaysian MFIs. On average, funds received were about 1,263 million (1,036 to 2,194 million). Above-average subsidy support for this trend is also evident in the case of MFIs in Malaysia (Mokhtar, 2011; Omar, 2018). The input and output data are slightly different, which might indicate various differences and technological changes. As shown above, the total number of branches, employees, and distribution of subsidies have changed slightly. This suggests that any advantage of controlling these inputs could vary in efficiency. Therefore, the significance of efficiency and technological change, and their impact on consumers and sustainable business growth, should be a subject for further research.

Table 1. Summary statistics on microfinance institution data.

Category	Variable	Unit	Mean	Minimum	Maximum	Standard deviation
Inputs	Total branch	Numeric	303	280	318	17
	Total staff	Numeric	3K	2K	3K	406
	Total subsidy	Myr	1236M	1036M	2194M	8276
Output	Total borrower	Numeric	350K	247K	421K	57

Note: K – Thousand; M – Million.

According to microeconomic theory, the prime input used in production is labor and capital (Parkin, 2020). The procedure involves three inputs and one output, as indicated in the table below. According to MFI, technical efficiency is achieved when the combination of inputs and outputs is optimized at a given level of technology, with inputs (x) producing outputs (y). The input parameters are total branches, total staff, and total subsidies (x1, x2, and x3). The variables in the output are the total borrower (y1) used as estimates in this study, as shown in Table 2.

Table 2. Input and output selection.

Variable name		Definition	Notation
Input	Total branches	The total number of branches includes the head offices of MFIs.	x_1
	Total staff	The number of people currently employed by MFIs.	x_2
	Total subsidy	Refer to the amount or fund received by MFIs.	x_3
Output	Total borrowers	The number of people currently having a loan with the MFI and responsible for repayment.	y_1

A strong test can be made to assess the reliability and validity of the results. Regarding DEA and Malmquist index, Wilson (1995) argued that the presence of outliers in these models can alter the shape of the production frontier, bias estimated efficiency scores and productivity figures. In addition, Banker et al. (1984) stated that the determination of CRS and VRS will have a significant impact on the results of the DEA Malmquist Index. Therefore, we propose a VRS model to accurately measure the source's ability. Consequently, this research detected and trimmed abnormal values in the dataset to reduce their impact on the results. We selected the VRS assumption because it provides more realistic measures of production. DEAP version 2.1 software is a popular tool for DEA and MPI calculations. The program calculates the Malmquist Index, efficiency change, and technological change for each DMU over the study period.

3.2. The Malmquist Productivity Index

The Malmquist productivity index, developed by Caves, Christensen, and Diewert (1982), extends the DEA framework by measuring changes in productivity over time, despite the availability of several indices such as the Tornqvist, Fisher, Paasche, and Laspeyres indices (Casu, Girardone, & Molyneux, 2004). The advantages of the MPI compared to other methods are that it does not require input and output prices and does not assume that the firm maximizes profit or minimizes cost (Grifell-Tatje & Lovell, 1996). The MPI measures the productivity growth of a firm and assesses the maximum output that can be obtained using its inputs. In other words, the Malmquist productivity index is a technique used to measure productivity changes over time by comparing the efficiency of Decision-Making Units (DMUs) between two periods. It decomposes changes into technical efficiency change (how well DMUs utilize their resources relative to the frontier) and technological change (shifts in the production possibility frontier), providing insights into productivity improvements (Ahmad, Khurizan, & Awang, 2024; Charnes, Cooper, & Rhodes, 1978).

The efficiency bank research Kiemo and Kamau (2021) and Gulati and Kumar (2017) identified three main approaches for measuring the productivity of banks and other financial institutions. Three main approaches used to measure the productivity of banks and other financial institutions are production, intermediation, and assets (Athanassopoulos & Giokas, 2000; Berger & Humphrey, 1997). This study used a production approach that assumes banks and other financial institutions are producers of deposits, loans, and providers of services, with accounts as the input. The number of accounts opened or transactions processed is the best measure of output.

This study employed the DEA-Malmquist index, which combines the strengths of both DEA and the Malmquist index. It leverages DEA to estimate the efficiency of DMUs in each period and then uses the Malmquist index to measure productivity changes, decomposing these changes into efficiency and technological changes. This combined approach is particularly well-suited for analyzing multi-input and multi-output production systems. It does not require the specification of a production function, making it flexible and adaptable to various contexts (Ahmad et al., 2024; Charnes et al., 1978). By combining DEA's efficiency evaluation with the Malmquist index's productivity measurement, it provides a more comprehensive and insightful analysis of DMU performance over time.

The integration of DEA with the Malmquist index calculates the total factor productivity (TFP) index and its components for MFIs during the period 2009-2020 in this study. An output-oriented TFP index model for VRS is employed in this research. The choice of this model is justified by the state of the MFIs industry in Malaysia, where MFIs receive financial support from the government, operate under strict regulations, and face intense market competition, all of which challenge MFIs to reach the optimal scale of operation (Hj Kassim, Kassim, & Othman, 2019). Another reason for selecting the VRS technology model is that it reflects firm-level data and is used to measure the degree of productivity in MFIs, also known as TFP (Athanassopoulos & Giokas, 2000).

Coelli, Rao, O'donnell, and Battese (2005) define the Malmquist index as a method that uses DEA to compare productivity at two different times by comparing the ratio of a quantity over two time periods. The Malmquist index was originally introduced by Caves et al. (1982) as a measure of productivity changes over time. The original

formulation, a distance function, of the index assumes constant returns to scale and was later generalized by Fare, Grosskopf, and Lovell (1994). Let the function that describes the production technology be given by $F(X, Y) = 0$, where $X = (x_1, x_2, \ldots, xm)$ is the input vector and $Y = (y_1, y_2, \ldots, y_3)$ denotes the output vector. Caves et al. (1982) define the output-based Malmquist productivity index in terms of a distance function as in Equation 1. This is done so that the performance of a production unit can be compared between periods t and t+1, using technology from period t.

$$M_0^t(X_{t+1}, Y_{t+1}, X_t, Y_t) = \frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)} \quad (1)$$

The alternative approach of computing efficiency over time with reference to period t+1 enables us to construct an output-based Malmquist productivity index in period t+1 technology as indicated in Equation 2, where M0 > 1 indicates that period t is more productive than period t+1.

$$M_0^{t+1}(X_{t+1}, Y_{t+1}, X_t, Y_t) = \frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_t, Y_t)} \quad (2)$$

To distinguish between the two methods of measuring productivity, which cover both time periods, Fare et al. (1994) recommended using the geometric mean of output-based Malmquist productivity index in period t and period t+1 technology represented by Equations 3 and 4. Fare et al. (1994) added efficiency changes and technological changes under constant return to scale with convexity constraints to allow variable return to scale in the distance function.

$$M_0\,(X_{t+1}, Y_{t+1}, X_t, Y_t) = \left[\left(\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)}\right)\left(\frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_t, Y_t)}\right)\right]^{\frac{1}{2}} \quad (3)$$

$$= \left(\frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)}\right)\left[\left(\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_{t+1}, Y_{t+1})}\right)\left(\frac{D_0^t(X_t, Y_t)}{D_0^{t+1}(X_t, Y_t)}\right)\right]^{\frac{1}{2}} \quad (4)$$

Where,

- $Efficiency\ change = \left(\frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)}\right)$
- $Technological\ change = \left[\left(\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)}\right)\left(\frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_t, Y_t)}\right)\right]^{\frac{1}{2}}$

Equation 4 shows that the terms outside the bracket represent the change in efficiency (EC) from period t to t+1, while the terms inside the bracket represent the technical change (TC) evaluated between the two time periods at (X_t, Y_t) and (X_{t+1}, Yt_{+1}). Here, the overall Malmquist productivity index is measured by multiplying the efficiency and technical changes. The Malmquist productivity index (MPI) is employed to assess productivity changes between two datasets across different periods. This assessment results from the product of the relative change in efficiency occurring between times t and $t+1$, referred to as the catch-up effect, and the technological change occurring in the same interval, known as the frontier shift effect. If M0 > 1, productivity improves over time; if M0 < 1, productivity decreases; and if M0 = 1, productivity remains constant.

4. EMPIRICAL RESULT

Following the approach used by Fare et al. (1994) the productivity growth of MFIs in Malaysia has been estimated using a selection of an output-oriented Malmquist Index model and resolution of the linear programming provided by the DEAP 2.1 program, which estimates the variation in variable efficiency forms and total factor productivity between two consecutive periods. The findings do not classify t-1 in the first year and t+1 in the final year because all the values were calculated for year 1, as there was no data available for the year before year 1. The period during which this research was conducted was between the years 2009 and 2020; hence, the first index summary will begin from the year 2010, as shown in Table 3 below, which also shows the index summary of 11 years in total, showing the transition between the two periods. The outcomes will be calculated as a percentage by subtracting 1 from the corresponding index value and multiplying it by 100.

The index value, being more than one, indicates favorable productivity growth or improvement (TFPCH). Less than one indicates productivity growth or a fall in the given period. To provide data on the productivity growth caused, the Malmquist productivity index is broken down further into technical efficiency change (EFCH) and technological change (TECH), such as TFPCH = EFCH X TECH. A TECH change is viewed as a shift or development of the best practice frontier. On the other hand, an EFCH shows the frontier movement of the industry, and if a unit is comparatively more efficient, it is said to "catch up" with the frontier. The EFCH is also broken down into the scale efficiency change (SECH) and pure technical efficiency change (PECH). To interpret the differences between the observation periods of MFIs in this study, the average index value can be interpreted in five categories as aforementioned: EFCH, TECH, PECH, SECH, and TFPCH, as presented in Table 3 below.

First, EFCH quantifies the extent of technology diffusion or technological knowledge usage and then uses that information for the estimation of efficiency change or catching-up effect for a firm moving towards or away from the frontier of optimal production. The EFCH outcomes from 2010 to 2020, as illustrated in Figure 1, demonstrate that the index does not vary for any increase in efficiency, except in 2010, when MFIs recorded an 87.5% rise in positive change. The remainder of the sum staying constant translates into no increase in efficiency at all. The fact that the EFCH measure of 1.059 is above 1 reflects that there have been gains in the change in efficiency or catch-up effects from the frontier of best practice are taking place for more effective use of inputs already available. These results agree with Jaiyeoba, Adewale, and Ibrahim (2018), who found that due to better management practices, MFIs' EFCH in Bangladesh and Indonesia are roughly efficient under CRS, VRS, and scale. All the while that this is so, the Malaysian EFCH results show that Malaysian MFIs need to exert more effort to spread technology and improve their technological know-how. These findings further support Jalil's (2021) assertion that Malaysian MFIs exert a positive and significant influence on the growth of rural microenterprises. However, to offer cost-effective products to these firms, MFIs must also develop digital finance. To better serve clients in Malaysia's base of the pyramid market, MFIs must further innovate their financial services, even in the face of government incentives offered to them through development policy.

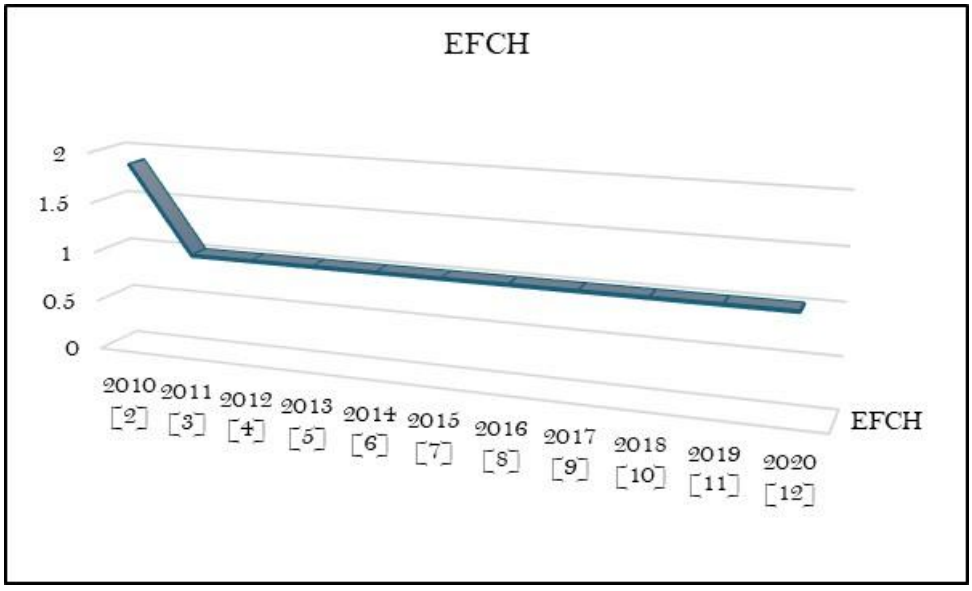

Figure 1. Technical efficiency change (EFCH) index.

Second, the progress of the border shift between two different periods for technological adoption and innovation is indicated by TECH, the second impact. The technological regression or decline in MFIs during the study period is reflected in the TECH results. The TECH index score in 2010 indicated a decline, as it was at the lowest percentage score of 58.8%; the highest scores reported were 11.9% in 2011 and 11.1% in 2017. This indicates that MFIs with a

score below one experienced an average TECH decline of 11.4%. In other words, there is still insufficient uptake of new technologies. Technological advancement is a feature of the finance revolution (Koh et al., 2021) because it is one of the prime innovation components needed to achieve a revolution in payment systems towards a finance revolution (Okoye, Omankhanlen, Okoh, Ezeji, & Achugamonu, 2019). One aspect that digital finance improves is service efficiency. Given the TECH evidence of technological withdrawal, MFIs in Malaysia must persistently enhance technology adoption to stay ahead of advancements in operational management. The importance of striving has also been illustrated by Mushtaq and Bruneau (2019) in the comprehensive research needed to adopt new digital finance technologies into Malaysia's microfinance context (Jalil, 2021).

Thirdly, both PECH and SECH are derived from EFCH and indicate improved management practices and optimal scale, respectively, given that the index score is greater than 1. In Table 3, the PECH score is equal to one for all the sampled study intervals in this research. A score equal to 1 means the optimal learning process for management practice in MFIs remains the same. The SEC indicates that the optimal size of MFIs improved by 87.5% in 2010 while remaining unchanged subsequently through the analyzed timeframe, meaning the firms' capacity to achieve maximum output with their given input level was unchanged (Balk, 2001). Our observations through the SEC results indicate Malaysian MFIs revert to a constant scale. Kumar and Gulati (2008) and Kumar and Gulati (2009) stated that it takes an MFI some effort or time to adapt to the operational strategy so that it may compete in a competitive marketplace. This is similar to microeconomic rationale; firms should pursue CRS and operate at their optimal productive scale, regardless of actual scale (Kumar & Gulati, 2008, 2009). The adaptation and shift in the operational strategies of Malaysian MFIs due to the 11th and 12th Malaysian Plans have influenced their operational progress. This knowledge is important for policymakers and industry players who wish to assess how they compare with the capabilities of Malaysian MFIs in terms of size to compete in the future.

Fourth, this study will quantify the productivity growth of Malaysian MFIs between two points in time by total factor productivity change (TFPC), often called the Malmquist TFP index (MPI). As discussed previously, productivity growth (change) can be explained by changes in EFCH, TECH, or both, as determined by MPI (Fare et al., 1994). Table 3 provides a summary of productivity changes during the period. If TFPC is greater than 1, it indicates that MFI output has increased, whereas TFPC values less than 1 suggest declining MFI productivity. Overall, Malaysian MFIs are showing an average TFPC decline of 8.03 percent. The results indicate that the average EFCH growth rate increased annually by 5.9% over the sample period, while the TECH growth rate decreased by 13.4%.

Table 3. Malmquist index summary of annual means.

Year	EFCH	TECH	PECH	SECH	TFPCH
2010 [2]	1.875	0.412	1.000	1.875	0.773
2011 [3]	1.000	0.881	1.000	1.000	0.881
2012 [4]	1.000	0.977	1.000	1.000	0.977
2013 [5]	1.000	0.972	1.000	1.000	0.972
2014 [6]	1.000	0.903	1.000	1.000	0.903
2015 [7]	1.000	0.936	1.000	1.000	0.936
2016 [8]	1.000	0.901	1.000	1.000	0.901
2017 [9]	1.000	0.883	1.000	1.000	0.883
2018 [10]	1.000	0.967	1.000	1.000	0.967
2019 [11]	1.000	0.950	1.000	1.000	0.950
2020 [12]	1.000	0.962	1.000	1.000	0.962
MEAN	1.059	0.866	1.000	1.059	0.917

Note: t-1 in year 1 and t+1 in the final year is not defined (All the values calculated based on the previous year), EFCH-Technical efficiency change, TECH-Technological change, PECH-Pure technical efficiency change, SECH-Scale efficiency change, and TFPCH-Total factor productivity change.

It is possible to identify the contributors to growth in productivity with a breakdown of the Malmquist Index. As stated above, EFCH and TECH are both specified as the product of the catch-up frontier shift terms defined by Cooper, Seiford, and Tone (2007). The term "frontier shift" or "innovation" refers to the change in the efficiency of

DMU frontiers over two periods of time (Cooper et al., 2007). The term "catch-up" or "recovery" means how much a DMU's efficiency strengthens or weakens. Technically, according to this research, EFCH, TECH, or both may be responsible for the declining and growing factors of productivity for Malaysian MFIs. Referring to Table 3, it is explicit that TECH was the main source of TFPC decline for Malaysian MFIs. TECH regressed by 13.4%, indicating that the peak precautionary or operational performance of Malaysian MFIs was declining. Additionally, while SECH contributes, with an average increase of 5.9%, this suggests that, overall, Malaysian MFIs have progressed toward an optimal size during the study period.

The findings of TFPC regression in this study are similar to those of Al-Awlaqi and Aamer (2019); Muneer Babu and Kulshreshtha (2014) and Bassem (2014), who reported lower productivity from TECH regression and concluded with a recommendation to adopt more advanced technologies to increase technological change. In the same environment, most SECH indices are equal to 1, thus indicating EFCH is constant over the years and implying that the low quantity of change in TFPC is a result of changes in technological change. As a result of TECH's low efficiency, overall productivity was less than 1% for Malaysian MFIs.

5. DISCUSSION AND POLICY IMPLICATIONS

The above empirical results clearly show that Malaysian productivity growth regressed by 13.4%, and findings indicate that TECH was the primary regressor influencing this change. The remedy involved addressing the first and second objectives of the current study. These results on EFCH, TECH, and TFPC impact consumers, business sustainability, and economic growth. The positive EFCH demonstrates that MFIs have made progress in utilizing accessible resources and becoming more efficient. In other words, consumers are experiencing improved service quality. However, consumers may not fully understand the benefits of digital financial services due to the regression in TECH. The decline in TECH also confirms that MFIs in Malaysia are experiencing delays in technology adoption. Moreover, this may hinder MFIs' ability to innovate in the long term. If the trend continues, the microfinance market niche could be overtaken by other financial service providers such as fintech and digital banking services, further reducing opportunities for unbanked consumers.

Since the TECH indicates that MFIs are not keeping up with new technological advances, it will severely affect the MFIs' long-term sustainability. The perennial PECH of 1 shows that management practices and learning processes have not improved over the years, and stagnation could hinder long-term growth and evolution, especially in a competitive setting where innovation is essential. Additionally, the SECH, particularly the significant increase in 2010, suggests that Malaysian MFIs have maintained an effective scale but not achieved intensive growth, as indicated by the negative TECH, implying a decline in technology from the perspective of sustainability. Malaysian MFIs may risk losing market share if they do not adopt upcoming digital tools or processes. Therefore, sustainability depends on accelerating technology adoption and continuous improvement in management practices. Furthermore, during this outcome stage, the TFPC regression, driven by the decline in TECH, could impair MFIs' performance and the microfinance sector's ability to support economic growth, especially in poverty reduction and entrepreneurship promotion. The regression in TECH and the subsequent decline in TFPC highlight the need for stronger technology adoption and ongoing innovation among Malaysian MFIs, with policymakers and industry stakeholders committed to ensuring this progress.

The negative TECH term highlights significant gaps in the adoption of new technologies, as well as microfinance institutions' (MFIs) lack of expertise and capital to drive technological innovation independently. Considering the observed technology regression (TECH) of 13.4% on average, Malaysian policymakers should prioritize digital transformation and innovation within the microfinance sector. Policies should include the adoption of advanced digital financial products and technologies, such as mobile banking and fintech platforms, to improve operational efficiency and better serve underserved populations (Koh, Orzes, & Jia, 2019; Okoye et al., 2019). Furthermore, policies need to provide room for systematic training programs to develop the technical competencies of MFI staff,

which will enable proper adoption and utilization of advanced technologies and creative financial practices (Jaiyeoba et al., 2018; Jalil, 2021).

Findings of stable scale efficiency (SECH) imply that Malaysian MFIs have remained at optimal operational scales throughout. To remain competitive, however, continuous adjustments must be made. Policymakers are advised to introduce regulatory incentives or scale efficiency maximization policies to encourage MFIs to continually review and optimize their operational scales and approaches, responding to changing market conditions while maintaining manageable costs (Kumar & Gulati, 2008, 2009).

To counter the technological backsliding that was harmful to Total Factor Productivity Change (TFPC), policies must include strategic incentivization for innovation mechanisms. These can take the form of tax incentives, grants for innovation, or preferential financial assistance to MFIs that are proactively investing in technological innovations and enhancing digital infrastructure (Al-Awlaqi & Aamer, 2019; Bassem, 2014; Muneer Babu & Kulshreshtha, 2014).

Cross-sector collaboration between MFIs, technology providers, and research institutions can stimulate knowledge exchange, collaboration in innovation projects, and technological innovation. However, collaborative co-development requires MFIs to work together with government, technology providers, and development partners to develop low-cost digital financial solutions for communities in absolute poverty, especially in rural undeveloped areas and bottom-level segments. To position MFIs for driving rapid digital innovation across the financial service ecosystem, there must be a clear effort to establish MFIs within national development plans. The last two Malaysia Plans (11th and 12th) make it clear that new policies and incentives can be used to strengthen MFIs' strategic business plans. For a more plan-based and proactive approach, MFIs could work towards integrating digitization and outreach targets into a national economic master plan to create a lasting focus and supportive financial policies. However, it is equally important to work with the ministries of rural development, technology, and finance to create a coordinated strategy for the promotion and access to frontier technology. Embedding these policy recommendations is likely to be less contentious and could foster a more active, inclusive, and efficient microfinance sector in Malaysia. Public-private partnership policies and strategies would assist in expediting partnerships for innovation adoption and best operational practices in the microfinance sector (Mushtaq & Bruneau, 2019). Of course, any analysis is always limited to data and preferred data is always updated data.

Furthermore, continuing observations over a long-term period could allow for more findings and technological pathways for regulation to support growth with changes in consumer, business, and economic development. Thus, even though the transferable nature of the results for the region's various countries is evident, this type of literature will contribute to the microfinance body of knowledge in Malaysia, representing the Southeast Asia region.

6. CONCLUSION

The study explored productivity growth and its implications for the purpose of sustainable business and economic growth. The objectives of this study were measured using the Malmquist Productivity Index over the period from 2010 to 2020. Based on a detailed literature review, it suggests a combination of three inputs and a single output: total branches, total personnel/staff, total subsidies, and total borrowers. The empirical results indicated that Malaysian MFIs had a mean TFPC regression of 8.03%. The average annual rate of EFCH increased by 5%, while the average TECH decreased by 13.4%. The PECH score was equal to 1, and the SECH fund indicated that the optimal size of MFIs increased by 87.5% in 2010 and remained stable thereafter. The main takeaway from this study is the finding that highlights the critical need for targeted policy interventions to address efficiency and technology gaps that exist for Malaysian MFIs. The spillover effect from engaging in digital transformation, innovation, and creativity will enhance the capacity of MFIs, serving as an enabler of sustainable business and economic growth. Additionally, consumers at the base of the pyramid will experience improved service quality, availability, and cost-effectiveness in financial services, which are essential for financial well-being, management, and entrepreneurship.

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Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
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