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Journal of Advanced Research in Business and Management Studies

Journal homepage:
https://karyailham.com.my/index.php/arbms/index
ISSN: 2462-1935

Financial Deepening Role to The Sustainable Development Pillars Achievement in Thailand: A Comprehensive Review

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ARTICLE INFO

Article history:
Received 18 May 2026
Received in revised form 28 June 2026
Accepted 5 July 2026
Available online 15 July 2026

Keywords:
Financial Deepening; Economic Growth; Environmental Quality; Income Distribution; Thailand

ABSTRACT

Financial deepening is focused in recent studies and plays a key role towards the country's sustainability success. Since Sustainability Development Goals (SDGs) 2030 agenda were adopted, economic growth, environmental quality and income distribution have been viewed as three pillars of sustainable development goals for every country. Currently, Thailand is developing their country extensively, however, Thailand's development is still an issue where the sustainable development pillars in each year are yet to align with the SDGs requirements attainment. A gap has been found as the financial deepening supply shows an uneven and mixed result for the three sustainable development pillars in Thailand. Therefore, by employing time series data analysis and several estimation techniques, the aim of this research is to investigate and confirm the correlation between financial deepening and the sustainable development pillars in Thailand. Hence, the outcome of this research is to prove the financial deepening as the role to the sustainable development pillars achievement in Thailand and improvise the effectiveness of the financial deepening policy in Thailand.

1. Introduction

Sustainable development (SD) is crucial all over the world. All countries are competitively accelerating their economy, environment and income distribution to balance their sustainable development pillars as these pillars are important to attain the Sustainable Development Goals (SDGs) by 2030 [30]. The progression of SDGs pillars achievement is continuously remarked by members of all countries. After a few years of adopting the blueprint of SDGs 2030, since its announcement in 2015, the first SDGs summit was held on 25th September 2019, and the political declaration has agreed to gear up the SDGs agenda. One of the declarations made is to commit to the financial gap between sectors, stakeholders, international development cooperations, environmental sustainability and investments. Somehow, the SDGs' progression is still limited and

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https://doi.org/10.37934/arbms.42.1.155172

uneven across countries [54]. There must be a key factor that will continuously contribute to the SDGs' progression. Antonio Guterres, the United Nations (UN) Secretary General, mentioned in his report the financial services role, for example, financial deepening is one of the factors that are aimed at bridging the financial gap and supporting the achievement of the three SD pillars in countries [8][59].

Financial deepening, or financial asset supply, has gained popularity in many studies nowadays. It is believed that the financial deepening role is becoming more significant to support the ongoing development in many countries in achieving the SDGs 2030 [20]. It is crucial to study financial deepening and SD pillars as it is aligned with the national growth that proves the allocation of financial resources in supporting economic growth, apart from improving the quality of the environment and countries' income distribution [62]. Somehow, its role in the country's development escalation remains indefinite, especially in developing countries such as Thailand. Thailand has witnessed its country's development since 1970. For more than fifty years, Thailand has proved its commitment to development and has been escalating its growth in various sectors and activities. However, at the end of 2019, the Prime Minister of Thailand implemented the idea of increasing the debt level up to USD470 million, to help the country's continuous growth [12]. Unfortunately, Thailand's development is indirectly surrounded by debt, which has kept increasing year by year [13]. Before the Bank of Thailand (BOT) borrowed the amount of debt from the International Monetary Fund (IMF), Thailand's sustainable development pillars were already elastic to the internal and external environmental changes, along with the development phases. The economic real Gross Domestic Product (GDP) are increasing but inconsistent, while the environmental quality and income distribution remain moderate (Figure 3).

While Thailand was in ardent development, the sustainable development pillars need to be considered as well. Since Thailand is known as a middle-income country, it is doing its best not to be left behind and is constantly developing its country. To achieve the status of a developed country is not exclusively aimed at by Thailand, but also by other countries that are doing their level best to escalate their development to secure the upper-income status [90]. The financial deepening supply trend could be an assisting factor for the development in Thailand. Nevertheless, the instability of the financial deepening trend could discourage the economic real GDP increment, worsen the CO2 emissions and create more income inequality in Thailand, which will eventually deny the significant correlation between these variables. Moreover, by having a huge debt, sustaining the financial deepening will soon weaken Thailand's development, even though financial deepening is alleged to assist the country's growth progression [87]. Therefore, by using time series analysis, the aim of this research is to investigate and confirm the correlation between financial deepening and the three sustainable development pillars in Thailand, and improvise the effectiveness of the financial deepening policy in Thailand.

1.1 Financial Deepening Towards Sustainable Development Goals

As mentioned, financial deepening is supposed to be an aid to the SDGs progression in all countries. Since the SDGs were embarked on in 2015, the United Nations (UN) in the United Nations Conference Trade and Development (UNCTAD) has aimed for a 'trillions' amount of FDP supply in assisting countries' development [22]. The SDGs 2030 contain 17 goals that all countries should know, and the main agenda of these goals are to eliminate extreme poverty, end hunger, reduce inequality and protect the earth. Financial deepening can be seen as a crucial component for economic GDP and economic well-being in most well-developed countries in attaining the SDGs pillars [63]. It depicts that financial deepening is also vital in developing countries. Not only in economic GDP, but financial

deepening is believed to increase the environmental quality and social income distribution as well. This has been highlighted in the report by the Secretary General of OECD (2022) [59], where financial deepening is the financial resources to the SD pillars that align and will impact each of the 17 SDGs. Moreover, the SD pillars must be balanced as these three SD pillars are highly interconnected [4].

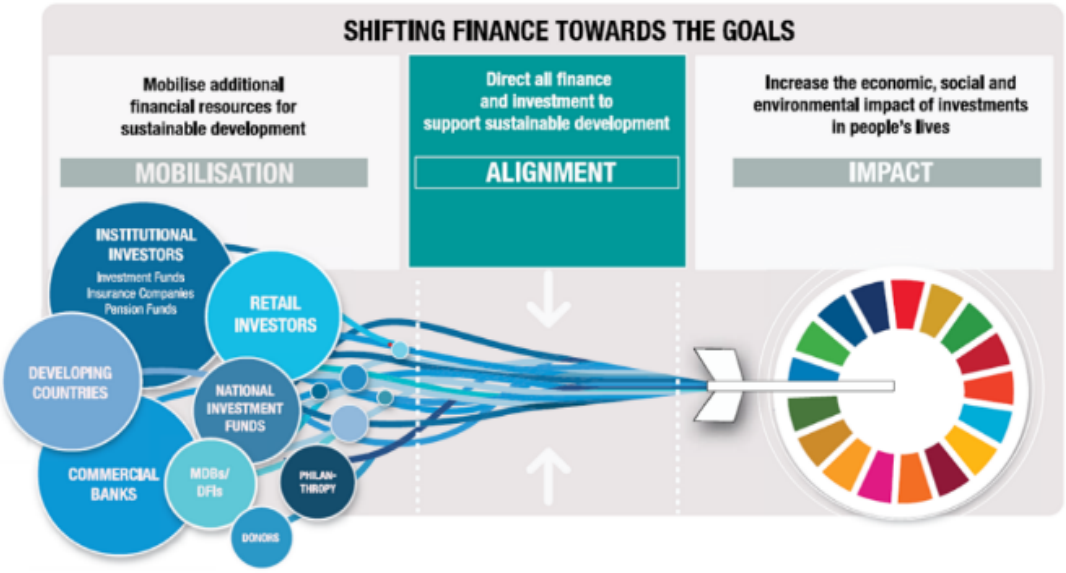

Fig. 1. A Three-step Approach of Financial Deepening (FDP) Towards the SDGs
Source: The Organization for Economic Co-operation and Development (OECD) [59]

It is reckoned that financial deepening is closely related to SDG 8, the economic growth, where financial deepening would help to promote, sustain and make sustainable economic growth inclusive in countries. Financial deepening is also closely related to SDG 13, where it would factor in combating climate change, which will eventually reduce the carbon dioxide emissions in countries. Moreover, financial deepening would be a factor in realizing SDG 10, which is to reduce the inequality of income distribution within and among countries [83]. A virtuous financial system in countries is highly crucial to ensure that the financial resources are mobilized and allocated. The insufficiency of financial resources will pressure future generations to fall into a huge debt, live in an unhealthy environment and refrain from receiving good and high earnings. As SD pillars are interconnected and are popular in concurrent studies, it is important to study the linkages of financial deepening and SD pillars, as they would be the determinants of the main factors for achieving the SDGs 2030.

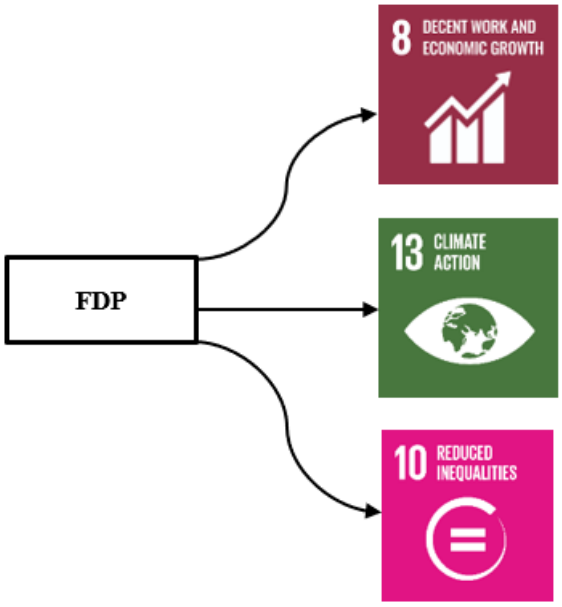

Fig. 2. Financial Deepening Pathways to SDGs
Note: Created by the author

Financial deepening contains several variables that have been absorbed in many countries' expansion such as credit to the private sector (CTPS), broad money supply (M2), stock market, deposit assets, deposit liabilities and investment. However, among all, CTPS and M2 were found as the utmost contributors to economic growth, specifically in well-developed countries and in ASEAN countries as well [15][5]. These variables were determined by important factors such as real GDP, interest rates, inflation rate and real exchange rate [24][6][51]. Thus, these factors are the influencing factors that could have either a positive or negative impact on the increment or decrement of financial deepening in countries. Thailand's economic growth, environmental quality and income distribution were having an unstable trend. By looking into these financial deepening variables, new policies could be suggested to Thailand's policymakers. Furthermore, with certain determinants as the influencing factors to the financial deepening, Thailand's financial deepening trend and SD pillars could be improved and sustained.

1.2 Thailand Financial Deepening and Sustainable Development Pillars Trend

Since the 1970s, Thailand's financial deepening trend and SD pillars have shown inconsistency (Figure 3). Even though the development progression was increasing, the economic growth, especially, was moderate and at an average level. Until 2024, Thailand's economic GDP has recorded only US$6,574.46 amounts of GDP per capita, relatively a slow growth from US$ 979.00 GPD per capita in 1970 [89]. In 1980, financial deepening was actively used as a financial resource for Thailand's development. During this period, financial deregulations were also permitted. The economic growth has escalated, and Thailand was above other ASEAN countries in the 1980s [35]. Somehow, during the development phases, the financial deepening trend was uneven, and non-performing loans (NPLs) had arisen in 1983. Due to cheaper borrowing as well, many domestic borrowers went offshore rather than choosing the domestic loan [45]. To overcome the inconsistent trend, financial liberalization in the financial system has helped Thailand in providing ample financial deepening to gain and improve the country's development.

Financial deepening expansion was competitive among banking sectors and other finance companies. Thus, the liberalization of financial sectors led to the continuation of Thailand's growth, and Thailand was once known as the "East Asian economic miracle" during that time [23]. Ultimately, Thailand experienced the highest economic growth until before the global financial crises happened from 1997 to 1999. Global financial crises impacted Thailand as its economy did not grow impressively, and Thailand has moved to focus on the debt market. As a consequence, it turned out that Thailand had to face the debt crisis, and the NPLs were also mounting, and the financial deepening trend continued to be uneven [79]. Not long after that, Mr. Thaksin, the former Prime Minister, reformed a new financial system policy that strengthens the domestic loan, investment and export activities in the country. Thailand's economic GDP progressively increased, but not the financial deepening. At the end of 2019, the Thai government signed up a New Arrangements of Borrowing (NAB) amounting to USD470 million from the International Monetary Fund (IMF) as a financial preparation for the country's future performance [12]. Thailand is able to maintain its financial deepening supply even though the trend records were uneven year to year.

Thailand's carbon dioxide (CO2) emissions were detected during the development progression. The CO2 emissions have been increasing year by year since 1970. But, in the 1980s, the CO2 emissions per capita were getting higher, up to 0.85 tons, and the trend kept increasing in an uneven way. Thailand was very active, especially in the agricultural and financial sectors, since financial deepening was involved in supporting the agricultural activities. Moreover, the financial system reformation made in the Financial System Development Plan (FSDP) also helps to promote financial deepening, especially in light industries such as computer manufacturing and assembly [78]. With less focused in huge development, Thailand was able to maintain a low rise in CO2 emissions per capita. Somehow, after a few years of development, financial deepening continuously increased, resulting in the CO2 emission reaching a high value of 2.99 tons per capita in 1997 (Figure 3). Thailand was enthusiastic to achieve the status of a higher-income country. But during the development phases, CO2 emissions were severely increased, and financial deepening was seen as one of the factors contributing to the emissions [70]. Thus, Thailand's environmental quality could not be sustained, and this situation continued during the global financial crises until 1999.

During Mr. Thaksin's ruling era, he continued the financial liberalization idea to keep a low financial deepening by focusing on rural development and export activities in Thailand. As a result, CO2 emissions in Thailand were able to increase at a low rate until the end of 2011. Then, the new Thai Prime Minister continued executing Mr. Thaksin's economic development policy after his era has ended. His idea was to increase production growth and energy usage in the local manufacturing sector, but somehow, the CO2 emissions could not be resisted, and they continued to be released until 2018 [18]. Noticeable effect can be seen in 2014, where smoke haze pollution (fuel and biomass) occurred in Northern Thailand, caused by the open burning, and led to a significant increase in CO2 emissions. This further resulted in a steadily increasing trend in CO2 emissions and Thailand had the highest CO2 emissions until 2016 [44]. This situation persisted until 2024, when the CO2 emissions recorded at 3.96 tons per capita, which is still relatively high. Following the financial deepening development phases and CO2 emissions in Thailand, it possible that financial deepening causes the continuous CO2 emissions.

At the same time, income distribution in Thailand shows an unstable trend, like other SD pillars too (Figure 3). GINI coefficient per capita has always been recorded at its highest point since 1970. The highest GINI coefficient that Thailand has experienced was in 1977, at 5.14 per capita. This has led to a low-income distribution, which creates inequality among the population. Year by year, the GINI coefficient was unevenly increasing, and this was not good for Thailand. A previous study has mentioned that Thailand's income inequality was related to the financial deepening [58] as both

financial deepening and the GINI coefficient trend were recorded to be uneven. Global financial crises gave a slight relief to Thailand when the GINI coefficient dropped a little, along with a drop in the financial deepening. However, in a one-year duration, income inequality increases again. Since the implementation of Mr. Thaksin's new development policy, income inequality of Thailand's population became unstable, and the GINI coefficient is not in line with the new financial system reformation made [3]. This scenario was not parallel with the theory mentioned by Ridzuan *et al.,* [67] that when high financial deepening is supplied in countries, the income inequality will be reduced. However, during the global recession from 2007 to 2009, financial deepening was low, and the GINI coefficient was also low, which signifies that income inequality is reducing in Thailand.

Not too long after that, there was some progress in the trend of financial deepening in 2011. Thailand had rapidly grown as a country, yet this does not apply to the GINI coefficient per capita, which continued to increase until 2013. From 2014 until 2024, Thailand recorded a little improvement in its GINI coefficient per capita. It declined to 3.9 per capita, a slight decrease compared to eleven years ago, when it was 4.2 per capita. Ideally, financial deepening increment should reduce the income inequality [21]; nonetheless, Thailand's situation did not show the same. Financial deepening in Thailand is not synchronized with its GINI coefficient performance year by year, as income inequality was still happening until 2024. Since the beginning stage of its economic development, Thailand's income distribution has become a vital issue. The income inequality occurred and formed the GINI coefficient of Thailand to be at the lowest performance [86]. It is admitted that Thailand increases its country's performance by depending more on financial deepening in various sectors. With the increment of debt borrowing, Thailand may strengthen their financial resources, but not their income distribution to the population.

1.2 Issue

Thailand was disrupted by several issues related to financial deepening and the three SD pillars. Financial deepening has become more resilient to economic and financial liberalization since the 1980s, which has led to financial deepening being more accessible to many industries and households in Thailand. Unfortunately, the GDP growth remains at a moderate level. Financial liberalization then has turned out to be contrariwise when most industries and borrowers preferred external debt that was the cheapest, and by believing in no currency risk, Thailand's international debt rose significantly and until today Thailand is still surrounded by a debt issue [13]. The Thai government has decided to increase the NAB in year 2019 to sustain the financial resources that allow more financial deepening to increase the GDP, but consequently, it resulted in generating more debt with no economic growth [87]. When, essentially, high financial deepening is supposed to help the economy grow further, the GDP is not growing, and the over-supply of financial deepening could soon weaken Thailand's development [68][17].

Environmental quality in Thailand is also not performing well when CO2 continues to be emitted. As Thailand was robust and active in their development, it has led to more and unstoppable CO2 emissions [37]. Since the financial deepening supply has risen, the investment in green technology has become a good solution to combat the CO2 emissions in Thailand. However, as year increases, Thailand's active development has caused higher fuel burning and biomass burning, which makes Thailand a large source of CO2 emissions until today [74]. This situation contributes to climate change in Thailand. Despite the fact that the investment in green technology should support environmental quality, all industries were competitively increasing their profit while overlooking the issue of CO2 emissions.

Besides, Thailand's income distribution is still unimpressive. Even when the economy is gradually rising at an average level, income inequality is still happening in Thailand. Like other SD pillars, financial deepening is supposed to improve the income distribution, but not in the case of Thailand. After many years of financial deepening supply for the country's development, Thailand is still ranking at number four in the ASEAN region, with top 10% of the population that received 48.79% of total income making up below 50% since 1980 until today [85][58]. This led to the low GINI coefficient year by year. Much progress has been made to overcome the inequality issue, including increasing debt borrowing. Nonetheless, Thailand did not show much improvement and still has a high-income inequality that is misaligned with the country's development [88].

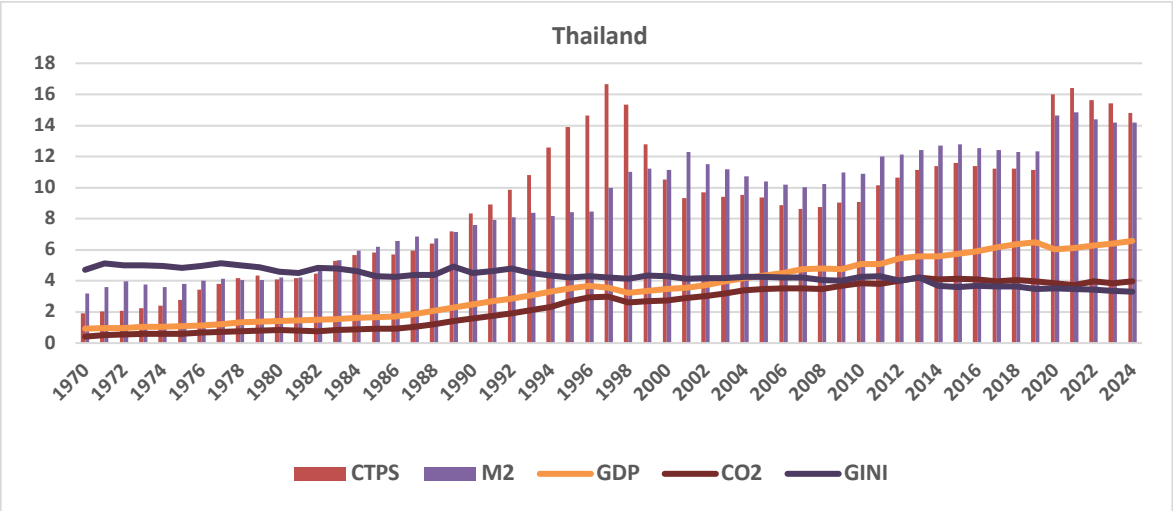

Fig. 3. Thailand Financial Deepening (FDP), Economic Growth (GDP), Environmental Quality (CO2) and Income Distribution (GINI) Trend

1.3 Literature Review

1.3.1 Financial Deepening Variables

Financial deepening (FDP) in this study is measured by credit to the private sector (CTPS) and broad money supply (M2), both variables which are widely recognized in the financial development literature as robust indicators of financial system expansion and efficiency [55]. The pioneering authors of finance and growth, King and Levine (1993), have established CTPS as a reliable proxy for financial services development, representing its strong association with long-term economic growth. Since then, numerous studies have adopted domestic CTPS as a percentage of GDP to prove the efficiency of financial services and their involvement in sustainable development outcomes [25][5]. In essence, CTPS replicates how effectively financial institutions provide funds toward productive private-sector and industrial activities, which are central to economic expansion and structural transformation.

At the same time, broad money supply (M2) provides a complementary measure of financial deepening by capturing the overall liquidity available within an economy. This variable is particularly relevant in developing countries, where banking systems play a dominant role in financial services. Prior research proposes that both CTPS and M2 are closely linked to economic growth and macroeconomic stability, as they reflect the scale and inclusiveness of financial sector development [2]. Empirical evidence from developed and emerging economies further supports the use of these variables as key proxies for financial deepening [7][29][53][61]. Therefore, the selection of CTPS and

M2 in this study is both theoretically grounded and empirically supported, ensuring reliability with established research practices in investigating the role of financial deepening in promoting economic stability and sustainable growth.

1.3.2 Economic Growth (GDP)

Economic growth, or referred to as economic development, describes the process through which an economy expands and transforms year by year. This growth is determined by increases in investment, labour force participation, improvements in production efficiency and technological advancement [41]. Economic growth is commonly measured using real gross domestic product (GDP) per capita, which functions as a key benchmark for policymakers in assessing the overall health of an economy and defining appropriate strategies to sustain growth [28]. While GDP growth shows improvements in output and macroeconomic stability, including inflation control, it does not necessarily reflect on environmental equality or income distribution. Most of the existing literature has focused on factors such as foreign direct investment (FDI), trade openness (TO), internal corporate governance (ICG), exports, and capital inflows as key elements of sustainable economic growth [66]. However, comparatively less attention has been given to financial deepening variables, specifically credit to the private sector (CTPS) and broad money supply (M2), particularly in the context of Thailand, despite its probable importance.

Generally, previous studies suggest that CTPS contributes to economic growth when financial resources are effectively supplied towards productive sectors and industries that eventually support the economic GDP expansion [81]. At the same time, other research indicates that M2 may employ a stronger and more stable significant impact on economic growth, as it reflects broader financial services and liquidity within the economy [38][60]. Similarly, Uchenna *et al.,* [80] found that while M2 has a significant positive impact on economic growth, CTPS might have a negative impact on economic growth. Despite these mixed findings, both CTPS and M2 persist as vital indicators of financial stability and economic development. The variation in empirical results suggests that the relationship between financial deepening and economic growth is complex and non-linear, emphasizing the need for further investigation.

1.3.3 Environmental Quality (CO2 Emissions)

Over the years, CO2 emissions have remained an unstoppable issue in many countries. Financial deepening and financial liberalization policies have been widely implemented to support economic growth. However, upon the development, CO2 emissions were increasing and caused the environmental quality to drop [16]. Despite these concerns, financial deepening is set to play an important role in many countries' development strategies and remains a key element of the endeavour to stimulate economic growth and financial sector improvement. The Kyoto Protocol has been recognized by many countries as an important mechanism for promoting a green environment. It was intended to decrease greenhouse gas emissions while allowing countries to continue their economic expansion without significant disruption [82]. However, as climate change has intensified over time, progress toward achieving the Sustainable Development Goals (SDGs) has been distracted and increasingly faced challenges as well. Simultaneously, the financial system, including financial deepening, was intensely affected, as climate change is risky and its uncertainties will influence investment patterns, capital allocation, and overall economic stability in countries [49].

Khan *et al*., [43] investigated the relationship between financial deepening, FDI, economic growth and renewable energy consumption as the immediate variables on the CO2 emissions worldwide.

The financial deepening included the CTPS and M2 proxies. Their findings expose that financial deepening and economic growth are the most influential factors in the CO2 emissions increment worldwide, thus, it shows a positive correlation to indicate environmental degradation. While the rest of the variables were not. The same goes with Paramati *et al*., [63] as they found that the rise of financial deepening, specifically in 25 OECD countries, are highly correlated to the CO2 emissions. This depicts CTPS and M2 should be formulated by policymakers. But indifferent with [26] that explored the financial deepening role as a dominant factor on the environmental quality in emerging economies, developing countries, Asian, EU, Latin American and non-oil producing countries. While oil-producing and Arab countries are the countries that produce CO2 emissions, these countries vastly contributed to environmental degradation compared to the other countries mentioned.

1.3.4 Income Distribution (GINI Coefficient)

Income distribution plays a crucial role in ensuring social stability and inclusive development. It replicates how income is allocated among individuals in society, including wages earned from labour and returns generated from business capital ownership [31]. The most commonly used measure of income inequality is the GINI coefficient, which tells the degree of income dispersion within a population [50]. Financial deepening through the provision of credit and money supply could enhance productivity and spur economic growth. As mentioned in theory, sustained GDP growth may improve income distribution and promote greater equality. However, empirical findings on the relationship between financial deepening and income distribution remain mixed, with studies reporting varying results across different countries.

Rachmawati *et al.,* [64] investigated financial deepening and income inequality in Indonesia. By employing the Vector Error Correction Model (VECM), Dicky-Fuller test, the Optimum Lag Test, and the Johansen Co-integration Test, they found that financial deepening is significantly related to income inequality. In detail, M2 is more elastic and has the potential to increase income inequality in the long run. But, in the short run, CTPS has a negative relationship with income inequality. It shows that more financial deepening helps with income stability, but not in the long run. A study made by Shi *et al.*, [72] revealed that financial deepening is significantly positive proved at the causal of high-income inequality in Australia. Shi *et al*., [72] then suggested a suitable policy to emphasize financial deepening as an important driver across industries and society, providing lending and borrowing funds to improve income distribution in the country. Contrary to [14], which found that financial deepening is significantly negative to the income inequality in Turkey. Not only has Turkey reduced their poverty rate in the country, but they eventually reduced the gap between low and high-income groups.

2. Methodology

Time series analysis and specific estimation techniques will be employed to further conduct this interesting topic in answering and supporting the aim of the research. The estimation techniques, such as Principal Component Analysis (PCA), unit root test, ARDL cointegration test, diagnostic test and ARDL short run and long run elasticities test, will be conducted to clarify the issues mentioned. Quantitative and secondary data collection methods are suitable for finance, macroeconomics studies in the knowledge and education sector, development management of economy and others. Thus, this research is classified as a quantitative study, and all the secondary data needed will be collected from reliable sources, which are the World Bank database and other relevant sources. This would help researchers to obtain answers from empirical evaluations to provide resolutions along

with the new theoretical foundations constructed for the research [76], and importantly, to confirm the correlation between financial deepening and the three SD pillars in Thailand.

2.1 Data collection method

To clarify the findings and answer the research aim, the researchers will collect all the data needed from the World Bank database and conduct the required tests needed. Other than the World Bank, researchers will absorb the data from other relevant sources such as the International Monetary Fund (IMF), Thailand's Central Bank and Department of Statistics, and the United Nations Conference on Trade and Development (UNCTAD). All the variables are reliable, and the year-data selected is from 1970 to 2024. A 54-year series of analysis will be conducted with the techniques mentioned.

2.2 Estimation Techniques

2.2.1 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a preferable method to solve any dataset problem in a secondary study. Employing PCA helps researchers to reduce and simplify any complex dataset that consists of numbers of variables to be tested. This method will transform the independent variables into key components to avoid any redundancy when the variables are highly and linearly correlated [56]. Then, the dataset will compute the eigenvalues and eigenvectors correlation matrix into orthogonal axes set [32]. From that, researchers can analyse the data more efficiently and effectively to confirm the relationship between the variables tested in the short and long run. This will give a better view of the independent variables as the macroeconomic growth proxies.

2.2.2 Unit Root Test

The unit root test is a statistical technique used to examine whether a time series variable is non-stationary by testing the occurrence of a unit root under the null hypothesis. It is commonly applied in econometric models to assess the time-series properties of variables before estimating linear regression relationships [34][71]. Conducting a unit root test is critical to avoid any spurious regression results, which may arise when non-stationary variables are used in empirical analysis. In this study, three commonly used unit root tests, the Dickey–Fuller (DF), the Augmented Dickey–Fuller (ADF), and the Phillips–Perron (PP) tests, will be conducted.

2.2.2.1 Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF)

Dickey-Fuller test and Augmented Dickey-Fuller Tests are statistical tests to determine the reliability of time series data that do not change from time to time. DF and ADF statistical tests are significant on the time series data trend behaviour and to estimate the consistency of the data problem [57]. Besides, this unit root test will also help researchers to reprimand the non-stationary problem among the data series [39][42]. Thus, this research will employ DF and ADF statistical tests to see the consistency of Thailand's time series data between the financial deepening and economic growth (GDP), CO2 emissions and GINI coefficient.

2.2.2.2 Phillips-Perron (PP)

Similar to DF and ADF, the Philips-Perron test will be employed to determine the long-run correlation of the non-stationary variables tested in a study. This test will assist researchers in hypothesis testing of variables tested and to correct the nonparametric of the t-statistic test that arises from the DF and ADF test [36]. From the PP test, it can help to detect the variance of error terms in a regression model that are not constant between dependent and independent variables [1]. This situation is known as heteroscedasticity. Therefore, this research will conduct the PP test to observe the variables tested.

2.2.3 Autoregressive Distributed Lag (ARDL)

Next, this research will conduct the Autoregressive Distributed Lag (ARDL), also known as the Bound test, to formulate the econometric model to show the relationship between the economic variables in a single equation of time series data. This ARDL method, formulated by Pesaran, Shin and Smith (2001), is a very useful technique to enhance the error correction (EC) process while doing the cointegration analysis [47]. The ARDL bounds testing approach allows for reliable estimation of long-run relationships among variables without requiring prior confirmation of whether they are integrated at order zero, I(0), order one, I(1), or a combination of both [48].

2.2.4 Diagnostic Test

A diagnostic test is beneficial in identifying irregular parameters that are incorrectly defined in a regression model [52]. Since no empirical model is perfectly specified, the diagnostic test helps researchers to evaluate the adequacy and goodness-of-fit of the estimated parameters in the regression model [69]. In this research study, several standard diagnostic tests will be conducted, including the autocorrelation test, the normality test, the heteroscedasticity test, the Ramsey RESET Test, the Cumulative Sum (CUSUM), and the Cumulative Sum of Squares (CUSUMSQ) Stability Test.

2.2.4.1 Autocorrelation Test

In detecting the presence of serial correlation in the error term, an autocorrelation test will be conducted to identify the cause of potential problems within the econometric regression model. This test helps to explain the dynamic behaviour of the observed time-series data and ensures the reliability of the estimated results [73]. Among the available autocorrelation test methods, the Breusch–Godfrey (1978) is the best robust approach because it allows the presence of lagged dependent variables and is flexible in detecting higher-order autocorrelation [84].

A simple regression model equation of autocorrelation is Yt=β1+β2Xt+ut by using ordinary least squares (OLS) to acquire a set of sample residuals $\hat{u}t$. Then, Breusch and Godfrey improvised the secondary regression model equation as follows:

$$\hat{u}t = \alpha 1 + \alpha 2Xt + \hat{\rho}1\hat{u}t - 1 + \hat{\rho}2\hat{u}t - 2 + \cdots + \hat{\rho}p\hat{u}t - p + \varepsilon t \quad (1)$$

Before conducting the Breusch–Godfrey test, the Durbin-Watson (DW) test will be employed prior to observing the serial correlation of the data series with the rule of thumb from zero to four.

2.2.4.2 Normality Test

The second diagnostic test for this study is the normality test. This test will help researchers to review the normal distribution of financial and economic data in the study. The Jarque–Bera (JB) test is appropriate for the residuals acquired from an ordinary least squares (OLS) linear regression model with an intercept error. The JB test combines the squared values of normalized skewness and kurtosis into a single test statistic to evaluate whether the residuals diverge from normality [46].

Thus, the JB statistical model can be seen as follows:

$$\mathrm{JB} = [\mathrm{n}/6]\,[\mathrm{S}\hat{}2 + (\mathrm{K}-3)\,\hat{}2 / 4] \quad (2)$$

It is noted that the skewness (S) value is 0 and the kurtosis (K) value is 3 for a normal distribution. Then, the constant asymptotic discrepancies for the JB test are 6/n and 24/n, respectively. If the JB value is significantly large, the normality assumption will be rejected when the p-value is very low. Eventually, the hypothesis can be rejected.

2.2.4.3 Heteroscedasticity Test

The third diagnostic test for this study is the heteroscedasticity test, which will help researchers to examine the variance of dependent and independent variables in the regression model. It can determine whether the error terms exhibit non-constant variance, which may affect the reliability of the estimated coefficients [11]. By conducting this heteroscedasticity consistent covariance matrix, or the HCCM test, the research can confirm that the estimated relationships between the dependent and independent variables are statistically consistent and that the regression assumptions are not violated [10].

2.2.4.4 Ramsey RESET Test

Ramsey Regression error specification test, or the Ramsey RESET test, was initially found by Ramsey (1969). The Ramsey RESET test is employed to perceive potential model misspecification and omitted variable bias in a regression framework [27]. This test is useful in identifying whether important explanatory variables have been omitted from the model, which may lead to biased or unreliable estimates. When relevant regressors are omitted, the correlation structure of the model may change, thereby misrepresenting the estimated relationship between the independent variables and the dependent variable. Thus, this RESET test is very crucial in testing the validity of the regression model's function in this study [19].

2.2.4.5 Cumulative Sum (CUSUM) and Cumulative Sum of Square (CUSUMSQ) Stability Test

The last diagnostic test for this study is the Cumulative Sum (CUSUM) and the Cumulative Sum of Squares (CUSUMSQ) Stability Test by Brown et al. (1975). These tests are extensively used to detect structural breaks in regression models using the ordinary least squares (OLS) method. These two stability tests are specifically suitable for economic and finance studies as they assist in assessing whether model parameters keep on unchanging over time [77].

Both CUSUM and CUSUMQ tests are also based on repetitive residuals, allowing them to assess the stability of both long and short-run correlations within the constructed model. These tests will examine to know whether any systematic changes occur in the estimated coefficients of independent

variables which extend the sequences of dependent variables. If the plotted figures continue within the 5% critical bounds, the null hypothesis of parameter stability cannot be excluded [33]. This indicates that the regression model is constant and there is no structural instability.

2.2.5 ARDL Long-Run and Short-Run Elasticities

Finally, the ARDL long-run and short-run elasticities techniques will be conducted to confirm the correlations of all the variables tested in this study. After the non-stationary data is detected, complex data has been resolved, and the five-unit root tests are done, these ARDL elasticities will provide the results that integrate both long-run and short-run dynamics from the unrestricted error correction model (UECM) using a simple linear specification. The UECM in ARDL bound F captures the underlying data-generating process in a structured and systematic way, including the lagged variables [75]. Thus, this technique is chosen over the traditional regression method because the regression captures short-term, cyclical or seasonal effects.

The UEM transformation of all models is constructed according to the research objectives that consist of financial deepening and the SD pillars. Residuals for the UECM should be consecutively uncorrelated, and the model should be constant. The null hypothesis of no co-integration, in contrast to the alternative hypothesis of the existence of long-run co-integration, is defined by both long-run and short-run models.

3. Conclusion

The role of financial deepening is closely related to the attainment of the Sustainable Development Goals, particularly SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action). Over the past five decades, especially after periods of economic crisis, the expansion of financial systems in Thailand has influenced economic growth, income distribution, and environmental quality in different ways. While financial deepening has supported economic expansion and investment, contributing to SDG 8. However, the progress across social and environmental dimensions has been less consistent. Thus, volatility in financial and macroeconomic trends has resulted in uneven development outcomes across the SD pillars in Thailand. Thailand should learn from well-developed countries, such as Denmark, Norway, and other OECD members, that have demonstrated that their strong financial systems can promote sustainable economic growth while maintaining social welfare and environmental quality.

The existing studies on financial deepening in other developing countries tend to concentrate on economic growth, with limited exploration of its relationship with CO_2 emissions [40] and the GINI coefficient [65]. Somehow, the United Nations General Assembly (2019) has highlighted that achieving the SDGs 2030 requires stronger financial mobilization and synchronized efforts from public and private sectors to bridge the financing gap [9]. With regards to the issue mentioned, examining the linkage between financial deepening, GDP, CO_2 emissions, and income inequality in Thailand is necessary to provide clear evidence and strengthen the understanding of how financial deepening can contribute to the integrated achievement of the SD pillars balance in realizing the SDGs 2030. The effective financial deepening can aid as an instrument to stimulate inclusive growth, reduce inequality, and support sustainable environmental practices when properly aligned with national development strategies to bridge the financing gap in Thailand. Therefore, the findings from this study will assist Thailand to improve its policy and strategies in fostering the country's future. Also, the results will contribute to the future literature and research endeavours.

Acknowledgement
This research was not funded by any grant.

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