

Does Monetary Policy Affect Income Inequality? Evidence from Regional-level data in Thailand

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Abstract

This study investigates whether monetary policy affects regional income inequality in Thailand through different channels. The study uses regional-level data from 2011 to 2022 and employs a panel ARDL approach, FGLS and SUR estimates. Monetary policy effectively propagates regional income inequality through aggregate income channels, housing price channels, and interest rate channels. Those channels show that easing monetary policy can mitigate regional income inequality. A negative coefficient is found for the housing price channel, indicating that the easing of monetary policy induces an increase in housing prices but a decrease in rental prices, so the low-end distribution, who mostly cannot afford the house would benefit from a lower rental rate. In addition, Bangkok Metropolitan Region is more sensitive to changes in monetary policy than other regions. These findings suggest new insights for policymakers and the government an easing monetary measure can mitigate regional inequality via economic stimulation through various channels. Therefore, the central bank may need to consider the impacts of monetary policy on regional disparities, as each region has distinct characteristics that lead to varying effects.

Keywords: Monetary Policy, Income Inequality, Regional-level Model in Thailand, ARDL Approach, SUR Estimates

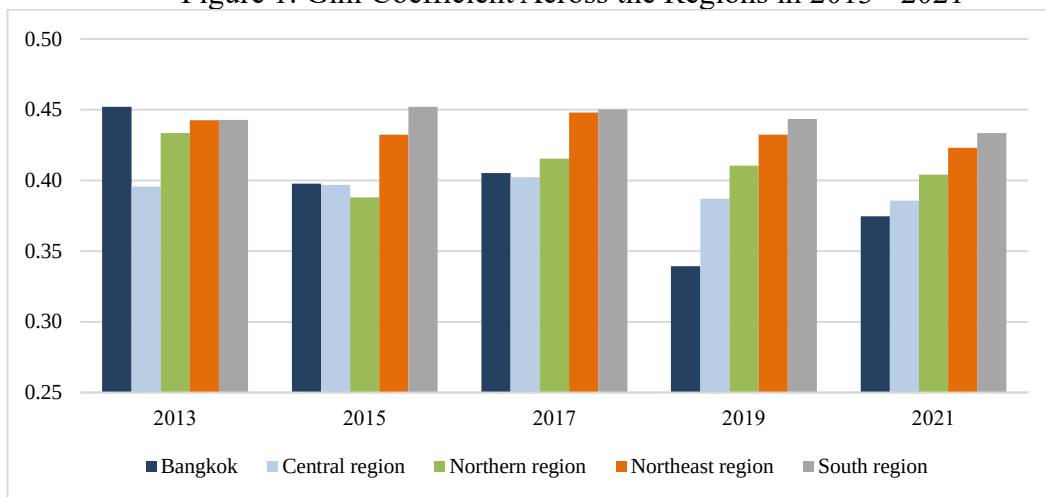
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1. Introduction

Even though Thailand's official poverty was reduced from 65.2% in 1988 to 9.85% in 2018, the gap between the bottom and top of the income distribution households still increases, indicating a rise in income inequality (Yang et al., 2020). The income inequality problem has been intense in rural areas since the economic development of the past decades. According to the data from the Office of the National Economics and Social Development Council (NESDC) in 2021, the most severe income inequality problem is in the Southern region, with the highest Gini coefficient at around 0.43, while the Central region has the lowest. The data in 2015 pointed out that the richest and the poorest in the Southern border region had an income inequality gap of around 20.6 times. The wealthiest group of households earns a share of about 41.4 percent of the total income in the region. In contrast, the poorest group of households has only 2% of the total income in the region (NESDC, 2015).

Figure 1: Gini Coefficient Across the Regions in 2013 - 2021



Source: Office of the National Economics and Social Development Council, 2021

According to Figure 1, income inequality in each region of Thailand has gradually decreased. The southern region has the highest income inequality, followed by the northeastern region. The issue of income inequality at the regional level in Thailand comes from several factors, including low wages in the agriculture sector, unequal resource access, and specific political issues and social conflicts in the southern border provinces. In addition, education inequities and limited infrastructure development contribute to these problems. As a result, economic opportunities remain concentrated in certain areas, leaving many other provinces with lower incomes. This issue also poses a challenge to Thailand's overall economic growth.

Various studies investigated the determinants of income inequality, such as economic development, globalization, financial development, and economic risks (for example, Greenwood & Jovanovic, 1990; Singh et al., 2009; van der Hoeven, 2019; Chiu & Lee, 2019). However, monetary policy is often ignored in the inequality model, which might be one of the primary factors causing income inequality. For example, a strict inflation-targeting policy led to an economic downturn, increasing unemployment and income inequality (Galbraith, 1998). However, this effect is quite ambiguous because of the different monetary policy transmission channels that can have positive

and negative impacts. In expansionary monetary policy, through an asset price channel, the negative effect is found as the top-income households should gain higher shares of financial earnings than the lower ones. In contrast, a saving channel creates a positive effect (Furceri et al., 2018).

Moreover, Albert et al. (2020) explored the housing price channel, which is part of the portfolio channel. His work noted that the monetary policy could change housing prices and rental rates, which affect the income of households that hold their wealth in housing. The expansionary monetary policy induces a rise in house prices, which would be a constraint for some vulnerable groups that want to buy houses and a benefit for high-income households with a more significant proportion of their housing wealth, increasing income inequality, while a low-income homeowner would not improve their well-being or consumption because of rising house prices.

Previous studies have examined whether Thailand's monetary policy significantly affects income inequality through various channels. Tapasanan & Ronaparp (2020) identified the effects through saving redistribution, earning composition, and the asset price channel. They found that the propagation of monetary policy via the asset price channel has more effect on high-income households than on lower ones, while the effects through savings remuneration are limited. Maneethai (2021) investigated the effect of inflation on income inequality in the case of Thailand and OECD countries and found a negative relationship between inflation and income inequality in Thailand, implying that contractionary monetary measures may reduce income inequality. Ruankham & Sethapramote (2023) use VAR and ADRL to establish a relationship between monetary policy and income inequality via various channels: the income composition channel, the interest rate channel, and the inflation channel. To measure the effect of income inequality, they use the income share of the top 1%, the income shares of the bottom 50%, and the Gini index as a proxy. Their research suggested that policymakers should examine the distribution impacts when setting long-term monetary policy objectives because expansionary monetary policy positively affects inequality. According to studies in Thailand, the effects of monetary policy on income inequality in the region have yet to be considered. Different regions may have various structures. Hence, monetary policy would have different consequences and impact real activities in different ways, which we incorporate into this study. To fill the gap, this study 1) investigates the impact of the regional-level model and 2) uses various transmissions, including aggregate income, earning heterogeneity, interest rate, inflation, and the housing price channel, which might have limited studies considered as one of the transmission channels.

In the next section, we discuss the empirical studies on the effect of monetary policy on income inequality through various channels. Section 3 sets out the econometric methodology to investigate the effects and how to measure income inequality. Section 4 provides the results from the ARDL approach and SUR estimates. Finally, Section 5 provides the conclusion and policy implication.

2. Related Literature

The monetary policy instruments that support price stability and economic growth have raised concerns about their disproportionate benefits to wealthy households because of increased asset prices. On the other hand, monetary expansion could benefit low-income households through increased employment and wage growth. This ambiguous effect of monetary policy and income inequality has become an exciting area of research and policy debate (da Silva, 2022). The relationship is further explored by

considering the income sources, mainly wages and labor incomes. The change in policy rate affects wages and labor incomes, which are significant sources of household income. While monetary policy also affects asset prices, households with financial wealth are more sensitive to changes in asset prices than low-income households.

Open market operations exemplify conventional monetary policy, which modifies the policy rate in response to macroeconomic developments. There are various hypothesized channels by which conventional monetary policy can influence income inequality. The nature of the population and the type of income, assets, and liabilities may affect the relationship. In sum, there are five main channels through which monetary policy may affect income inequality (Amaral, 2017 ; Coibion et al., 2017).

The first channel is the inflation tax. A rise in expectations in inflation could erode the purchasing power of consumer consumption. Inflation can worsen inequality, as low-income groups often lack the ability to safeguard their purchasing power due to limited access to credit and financial markets. This disproportionately affects low-income households compared to wealthier households (Glawe & Wagner, 2024). This expected inflation can be seen as a regressive consumption tax that heightens inequality (Erosa & Ventura, 2002). However, inflation can also mitigate inequality by reducing the real value of debt services. This suggests that the effects of inflation may vary between affluent and less affluent households. The increase in unexpected inflation, which comes from a monetary expansion, would erode the actual value of assets and liabilities, which makes the lenders worse off because the actual value of nominal debt decreases, while savers holding deposits face lower returns (Colciago et al., 2019). Numerous studies have found a connection between inflation and income inequality across countries, such as Romer & Romer (1998), Crowe (2006), and Albanesi (2007). In contrast, Binder (2019) found a negative relationship in their samples. Therefore, the relationships through this channel are not straightforward. The complex interplay between inflation, inequality, and the political and institutional context must be carefully considered.

Second is the saving redistribution channel, or interest rate income channel. Interest receipts and payments of formal financial sectors are adjusted in their lending rates to correspond with the policy rate. In an expansionary monetary policy, households that are net savers with short-term investments and net borrowers with long-term debts will gain. Although short-term investments would face low returns on short-term savings, they would benefit from lower interest rates, can increase investment opportunities, and may reduce the debt burden. Thus, even though the direct returns from short-term savings might be lower, there could be indirect benefits from lower borrowing costs and improved economic activity. For households that are net borrowers with long-term debts, a decrease in interest rates typically results in reduced borrowing costs as the effective interest burden on long-term loans decreases. As interest rates fall, reducing the real burden of debt payments. This particularly benefits borrowers with fixed-rate loans or other long-term financial obligations. This gain would be similar on the expenditure side for net savers with long-term investments and net debtors with short-term obligations (Auclert, 2019 ; Doepke & Schneider, 2006). The impact size depends on the holding proportions of those assets and their maturities.

Third is the earnings heterogeneity channel. The earnings heterogeneity channel refers to the mechanism in which changes in labour earnings across different groups of workers are transmitted within the labour market. Changes in monetary policy impact employment and wages differently due to differences in education, skills, experience, and specific economic sectors. This channel examines how monetary policy influences income distribution through two key mechanisms: wage and employment. In an economic downturn, firms may reduce labour costs by cutting jobs and wages among

lower-skilled workers while retaining high-skilled workers and higher pay. In contrast, expansionary monetary policy can stimulate economic activity and lower unemployment, which benefits low-income households, who are more sensitive to unemployment than other groups (Heathcote et al., 2010). When more people find jobs and their incomes rise, the income distribution may become more equitable, which could help reduce inequality.

The fourth channel is the income composition channel. This channel explores how monetary policy influences income distribution by examining various sources of income. According to Casiraghi et al. (2018), three components respond to changes in the policy rate: (1) labour earnings, (2) capital income and business income, and (3) transfers. Monetary policy can affect these sources of income in different ways. Individuals reliant on capital income such as interest and dividends may be more sensitive to interest rate changes than those who primarily earn wages. For example, easing monetary policy may reduce interest rate income, affecting households that rely on capital income, which often refers to upper-tail households, thus reducing income inequality (Colciago et al., 2019). Moreover, the aggregate income channel serves as the link between monetary policy and economic activity, which in turn affects overall income levels. Lower interest rates lead to higher consumption and investment, stimulating economic growth.

The last channel is the portfolio channel. Households distribute their wealth or income in asset portfolios differently regarding both the size and structure of the asset portfolio (Albert et al., 2020 ; Zungu & Greyling, 2022). Higher-income groups invest across various channels, such as bonds, stocks, mutual funds, and real estate. Therefore, expansionary monetary policy will increase asset prices, benefiting higher-income individuals more than lower-income individuals. This results in an increase in income inequality.

Table 1 summarizes the studies of the causal effect of monetary policy on income inequality in different scopes and their main findings. Most studies (for example, El Herradi & Leroy (2019); Punzi (2020); Ahiadorme (2022); Zungu & Greyling (2022)) found that monetary policy significantly impacts income inequality through various channels. The studies revealed that expansionary monetary policy widens the income inequality gap because it creates higher inflation, which directly affects the purchasing power and wage income of the lower-income households. On the contrary, wealthy households would benefit from an increasing business and capital gain in their holding assets when inflation increases. Hence, monetary policy significantly widens the income gap between lower and higher-income households, so the central bank needs to take this effect into their consideration.

Not only are the studies of monetary policy and dispersion of income inequality growing, but also wealth inequality. Wealth inequality is a snowball effect of rising income inequality, which has been quite moved in line with income inequality (Domanski et al., 2016). Wealth is basically described by financial and non-financial assets, including real estate, stocks, bonds, and others (Aye et al., 2020). According to Colciago et al. (2019), they explored many transmission channels in which monetary policy can influence wealth inequality, including savings redistribution, unexpected inflation, interest rate exposure, and portfolio composition. Several studies consider this relationship through portfolio channels and found that expansionary monetary policy has increased wealth disparity in most advanced countries (Domanski et al., 2016; Aye et al., 2020) This is because expansionary monetary policy enhances asset prices, so the value of financial assets held by the wealthy groups rises. For the unanticipated inflation

channel, expansionary monetary policy causes inflation, which redistributes wealth from lenders or savers to borrowers, reducing wealth inequality (Adam & Zhu, 2016; Meh et al., 2010). Most studies concluded that the effects of monetary policy on wealth disparity influenced the response of asset values and interest rates to a monetary policy shock, together with the combination of assets and debts in the family investments.

Table 1: Review of Empirical Studies

Authors	Countries/ Year	Model	Monetary Policy	Transmission Channel	Main finding
Inui et al., (2017)	Japan 1981-2008	- Local linear projection	Expansionary monetary policy	Earning heterogeneity and financial assets	(+) income inequality
Davtyan (2017)	USA 1979- 2012	- Vector auto regressive model	Contractionary monetary policy	Inflation	(-) income inequality
Fuceri et al. (2018)	32 advanced and emerging countries	- Local projection - Impulse response function	Contraction monetary policy shock	Labor earning	(+) income inequality
Mumtaz & Theophilopoulou (2017)	UK 1969- 2012	- Structural vector auto regressive model	Contractionary monetary policy	Income composition and Earning heterogeneity	(+) earning income and consumption inequality
Samarina & Nguyen (2019)	10 Euro countries 1999-2014	- Panel vector auto regressive model	Expansionary monetary policy	Inflation	(-) income inequality
Punzi (2020)	Japan 1981-2008	- Local linear projection	Expansionary monetary policy	Earning heterogeneity and financial assets	(+) income inequality
Ahiadrome & Worlanvo (2020)	Sub- Saharan Africa 1990Q1- 2016Q4	- Panel vector auto regressive model	Expansion un/conventional monetary policy	Earning heterogeneity	(-) income inequality (in partial equilibrium) (+) income inequality (in general equilibrium)
EI Herradi & Leroy (2019)	Advanced economies 1920-2015	- Panel vector auto regressive model - Local projection	Expansionary monetary policy	Income composition channel	(+) the share of notional income held by the richest 1 percent

Table 1: Review of Empirical Studies (cont.)

Authors	Countries/ Year	Model	Monetary Policy	Transmission Channel	Main finding
Park (2021)	Korea 1990- 2017Q2	- Vector auto regressive with block exogeneity	Contractionary monetary policy	Earning heterogeneity, saving redistribution, and income inequality	(+) income inequality
Magwedere & Marozva (2022)	South Africa 1990-2021	- Vector auto regressive base on impulse response functions	Expansionary monetary policy	Inflation (saving redistribution channel)	Non- responsive inequality to monetary policy shock
Zungu & Greyling (2022)	15 emerging countries	- Panel vector auto regressive model	Unconventional policy	Earning heterogeneity, income composition, portfolio channel	(+) income inequality

Source: Author's compilation based on the literature reviewed.

Besides monetary policy, there are macroprudential policies that may affect income inequality. Even though the purpose of macroprudential policies is to protect financial system stability and mitigate systematic risks arising from the vulnerability of financial sectors, they may have an impact on income inequality due to strengthening financial stability, reducing systemic risk, and reducing the probability of financial crises. Supporting a stable financial system leads to more accessible credit and increased employment and wages, which benefits low-income households and small businesses (Cerutti et al., 2017; Aiyar et al., 2014; Claessens et al., 2023). In addition, broad tax bases, including direct and indirect taxes and social spending, can reduce income inequality within a country and foster more equity up to 40%, especially in countries with high and moderate incomes (Granger et al., 2022)

Loan-to-value (LTV), debt-to-income (DTI), or reserve requirement is one of the macroprudential measures reducing the probability and conditional impact of a crisis - have direct redistributive effects on income inequality. Such policies would increase inequality at the initial stage because they limit the capacity of low-income households to acquire a loan or use their assets as collateral. However, those measures can reduce the increasing income disparities under adverse macroeconomic conditions by building capacity in the financial sector and preventing a collapse of the financial sector (Georgescu & Martín, 2021; Malovaná et al., 2023). Even though this may prevent low-income households from raising their income, such policies prevent them in crisis time. Therefore, macroprudential policies would smooth credit market and asset price movements over the financial cycle, potentially mitigating the financial stability concerns posed by foreign capital flows and leading to reduced inequality at the end. Liu, Guo, and Hu supported the idea that macroprudential measures, such as capital adequacy ratio, loan restrictions, loan-to-value limits, and deposit reserve requirements, mitigate income disparities in the case of China. On the other hand, some studies, such as Frost & Stralen (2017) and Konstantinou et al., (2023), found that borrower-targeted macroprudential measures have a positive relationship with income inequality, which means strict measures lead to higher income inequality because they create an obstacle

to the access of credit. However, this study will only focus on the effect of monetary policy on income inequality.

3. Methodology and Data

3.1 ARDL Estimated

To investigate whether monetary policy shocks lead to increased income inequality across the region in Thailand and see which channel of monetary policy is most affected, we use regional-level data from 2011-2022, including Bangkok & Metropolitan, the Central region, the Northern region, the Southern region, and the Northeast region. The dependent variable is income inequality, which is measured by the Gini coefficient. Our endogenous variables are transmission channels that include aggregate income, earning heterogeneity, inflation, and housing price. The ARDL and ECM models are represented as follows:

$$\Delta Y_{it} = \alpha_0 + \sum_{j=1}^n \delta_{ij} \Delta Y_{i,t-j} + \sum_{j=1}^n \vartheta_{ij} \Delta D.CPI_{i,t-j} + \sum_{j=1}^n \delta_{ij} \Delta GRP_{i,t-j} + \sum_{j=1}^n \gamma_{ij} \Delta HPI_{i,t-j} + \sum_{j=1}^n \alpha_{ij} \Delta EMP_{i,t-j} + \lambda_1 Y_{i,t-1} + \lambda_2 CPI_{i,t-1} + \lambda_3 GRP_{i,t-1} + \lambda_4 HPI_{i,t-1} + \lambda_5 EMP_{i,t-1} + \varepsilon_{it} \quad (1)$$

$$\Delta Y_{it} = \partial_0 + \sum_{j=1}^n \beta_{ij} \Delta Y_{i,t-j} + \sum_{j=1}^n \theta_{ij} \Delta D.CPI_{i,t-j} + \sum_{j=1}^n \alpha_{ij} \Delta GRP_{i,t-j} + \sum_{j=1}^n \delta_{ij} \Delta HPI_{i,t-j} + \sum_{j=1}^n \gamma_{ij} \Delta EMP_{i,t-j} + \eta \hat{\mu}_{i,t-j} + \varepsilon_{it} \quad (2)$$

where

Y_{it} = Gini coefficient in the region i at time t

$D.CPI_{it}$ = First difference of Consumer price index in region i at time t

GRP_{it} = Gross Regional Product in region i at time t

HPI_{it} = Housing price index in region i at time t

EMP_{it} = Number of employments in region i at time t

ε_{it} = disturbance term assumes to be a zero mean independent white noise process.

The first variable is the number of employment (EMP_{it}), refers to the earnings heterogeneity channel reflecting monetary policy's impact on household earnings and job status. Suppose the employment in lower- and middle-income households is high; in this case, the expansionary monetary policy will assist them by relieving the burden of looking for work and waiting for government payouts (Carpenter & Rodgers III, 2004). This might decrease income inequality, so the expected sign should be negative.

The housing prices index (HPI_{it}) was confirmed by literature, such as Claeys et al. (2015), Domanski et al., (2016) and Alves & Silva (2021), as a significant variable representing the portfolio channel. This is because real estate is a crucial part of a portfolio in some households. In this case, we use the detached house prices index to capture the portfolio channel. Those studies have generally found that an expansionary monetary policy leads to an increase in housing prices due to lower borrowing costs, prompting households to take out loans to purchase homes. However, rising housing

prices negatively impact low-income households, as they are unable to access homeownership, resulting in increased income inequality. Conversely, Albuquerque et al. (2024) found that expansionary monetary measures, which drive up housing prices, can actually benefit low-income households by lowering rental prices, which shift encourages households to buy homes, thereby helping to reduce inequality.

Gross regional product is expected to have a negative sign, implying that higher GRP mitigates regional income inequality. For inflation, expansionary monetary policy will lead to an increase in inflation, affecting the actual value of assets and liabilities. Therefore, this will benefit borrowers (low-income households), and a negative sign is expected, which is in line with the studies of Davtyan (2017) and Samarina & Nguyen (2019).

However, in panel data, cross-sectional dependence (CSD) is one of the most essential diagnostics that a researcher should investigate before performing a panel analysis. In this case, the estimated parameter using ordinary least squares will be inconsistent because of unobservable common shocks or cross-sectional correlation (Pesaran, 2006). Uddin & Sarntisart (2019) used Thailand's provincial panel data and found the CSD problem. This problem occurs because there is a dependence on economic outcomes across regions or provinces. Even though they are not neighbors geographically, they are also economically or socially connected. According to Pesaran (2006), the standard approach to deal with the cross-section dependence in panel data where the cross-section dimension (N) is small ($N < 10$) and the time series dimension (T) is large is seemingly unrelated regression equations (SURE) and then estimate the system by generalized least squares (GLS) techniques. This eliminates the individual specific effects and works when applying panel data where T is quite small. Moreover, spatial models are one of the tools that are used to deal with cross-sectional interactions. In these models, cross-sectional dependence is captured by spatial weights matrices based either on physical distance, relative positions in a social network, or on other types of economic distance. Hence, this study uses feasible generalized least squares (FGLS) as well to deal with cross-sectional correlation and heteroskedasticity problems and compare the results with those from the panel ARDL approach and FGLS analysis.

3.2 Seemingly Unrelated Regression (SUR)

This paper also applies the Seemingly Unrelated Regression Estimation (SUR) to test whether transmission channels, such as employment, gross regional product, housing price index, and consumer price index, serve as transmission mechanisms through which interest rates affect income inequality. The SUR is an econometric technique used to analyze systems of multiple regression equations with different sets of independent variables. The error terms across equations are correlated, although the dependent variables may differ. Using SUR allows for more efficient and accurate parameter estimation by accounting for these correlations in the error terms (Lewis-Beck et al., 2003).

In our equation each transmission channel is affected by interest rates and controlling variables. The error term from each equation may be correlated across these channels. Using this approach can account for the error correlated across equations, which means errors from one equation could influence the error in another. This leads to more reliable estimates and improves the validity of our analysis. Moreover, we can test whether the independent variables we use as a monetary transmission channel would be a proper transmission through which interest rates are affected. Hence, this approach also helps us to test the hypothesis more effectively by adequately considering the interdependencies between the error terms. The model that used SUR estimation is represented as follows:

$$LOGGRP_{it} = \alpha_0 + \alpha_1 INT_{it} + \alpha_2 LOGINV_{it} + \varepsilon_{it} \quad (3)$$

$$LOGEMP_{it} = \beta_0 + \beta_1 INT_{it} + \beta_2 LOGEDU_{it} + \varepsilon_{it} \quad (4)$$

$$LOGHPI_{it} = \gamma_0 + \gamma_1 INT_{it} + \gamma_2 LOGINV_{it} + \varepsilon_{it} \quad (5)$$

$$D.CPI_{it} = \delta_0 + \delta_1 INT_{it} + \delta_2 LOGCON_{it} + \varepsilon_{it} \quad (6)$$

$$\begin{aligned} LOGGINI_{it} = & \partial_0 + \partial_1 LOGGRP_{it} + \partial_2 LOGEMP_{it} + \partial_3 LOGHPI_{it} \\ & + \partial_4 D.CPI_{it} + \partial_5 INT_{it} \times REG1_{it} + \partial_6 INT_{it} \times REG2_{it} \\ & + \partial_7 INT_{it} \times REG3_{it} + \partial_8 INT_{it} \times REG4_{it} \\ & + \partial_9 INT_{it} \times REG5_{it} + \varepsilon_{it} \end{aligned} \quad (7)$$

where

$LOGGRP_{it}$ = Log of gross regional product in the region i at time t

$LOGINV_{it}$ = Log of newly Construction Area Approved in the region i at time t

$LOGEMP_{it}$ = Log of number of employers in region i at time t

$LOGEDU_{it}$ = Log of average year of schooling of household in region i at time t

$LOGCON_{it}$ = Log of average expenditure for consumption of household in region i at time t

$D.CPI_{it}$ = First difference of consumer price index in region i at time t

$LOGHPI_{it}$ = Log of housing price index in region i at time t

$LOGEMP_{it}$ = Log of number of employers in region i at time t

INT_{it} = Bilateral repurchase rate 1 day

$INT_{it} \times REG1_{it}$ = Interaction term between bilateral repurchase rate 1 day and dummy region (Bangkok Metropolitan Region)

$INT_{it} \times REG2_{it}$ = Interaction term between bilateral repurchase rate 1 day and dummy region (Central region)

$INT_{it} \times REG3_{it}$ = Interaction term between bilateral repurchase rate 1 day and dummy region (North region)

$INT_{it} \times REG4_{it}$ = Interaction term between bilateral repurchase rate 1 day and dummy region (Southern region)

$INT_{it} \times REG5_{it}$ = Interaction term between bilateral repurchase rate 1 day and dummy region (South region)

ε_{it} = disturbance term assumes to be a zero mean independent white noise process.

We use Seemingly Unrelated Regression (SUR) to determine whether the monetary policy transmission channels discussed in this paper—employment, consumer price index, housing price, and gross regional product—play a role in conveying the effects of monetary policy changes on income inequality. In equations 3-6, we run our model with the transmission channels as the dependent variables, while the change in monetary policy (represented by the interest rate, INT) serves as the independent variable, along with various control variables.

For the INT_{it} variable in equation 3-6, when monetary policy changes occur, we expect to have a positive effect on economic activity, employment, and investment. Specifically, when the policy interest rate is lowered to stimulate the economy, economic activity, employment, and investment are anticipated to increase, leading to rises in EMP, HPI, and GRP. Expansionary monetary policy can lower businesses' borrowing costs, leading to cheaper costs in investment. This increase in capital spending enhances production capacity and creates a greater demand for additional labor. As a result, lower interest rates can stimulate job creation and reduce unemployment. Similarly, in terms

of the Consumer Price Index (CPI), borrowing costs decline, households remain employed, and spending rises when interest rates are decreased, which leads to higher prices for goods and services. This aligns with Friedman (1968), which posits that monetary policy plays a crucial role in controlling inflation and promoting economic growth by adjusting the money supply and interest rates. According to Laokulrach (2011), monetary policy affects employment in the long term, as a reduction in interest rates can stimulate investment and consumer spending, positively impacting employment in the case of Thailand.

The interaction term is used in regression analysis to explore whether the effect of one independent variable on the dependent variable changes depending on the level of another independent variable. In this case, the interaction terms are the variables between the policy interest rate and regional dummy variables representing different regions. This study includes the interaction term in the model to examine how the impact of a change in monetary policy through the interest rate channel on income inequality differs across various regions in Thailand. Each interaction term allows us to see if the relationship between the policy rate and income inequality is stronger, weaker, or even reversed in different regions. For example, the coefficient for the interaction term $INT_{it} \times REG1_{it} (\partial_5)$ is positive. This suggests that in Bangkok Metropolitan Region, the effect of the policy interest rate on income inequality is more pronounced than in other regions. This means expansionary monetary policy may lead to a greater decrease in income inequality in Bangkok Metropolitan Region than in other regions. The interaction terms can better identify the region-specific effects of the policy interest rate on income inequality, providing a more detailed view of how monetary policy impacts different regional areas in Thailand.

3.3 The measurement of income inequality

A measure of inequality is used to describe a value-specific income distribution, which enables direct and objective comparisons between distributions. Inequality measures should have specific features that result in a specific event, but in fact, no single measure can satisfy these properties. As a result, choosing one measure over another includes trade-offs. This section examines the theoretical and methodological implications of various standard metrics of inequality.

The Gini index and Gini coefficient have been the most extensively used indicators of income disparity in economic and sociological research. The Gini coefficient measures how far an economy's distribution deviates from a completely equal distribution by calculating the ratio of the Lorenz curve to the 45-degree line. In addition, the Gini coefficient can be calculated by both income and expenditure. Both have advantages and disadvantages in measuring inequality. For the income method, it captures the household's ability to consume goods and services. Ali (2019) noted that the income method usually includes the present income and does not include other wealth assets, debt, or credit. The lower income groups may not spend their income for some goods, so without including these types of goods, this can mislead the ability of real spending on basic needs. For the expenditure method, it captures the well-being and permanent income more than the income method. The expenditure method is based on the subset of household total expenditure excluding taxes, pension funds, and other expenditures received from government programs. However, there are several alternative methods that exist and can help develop a more accurate knowledge of income distribution.

According to a Gini decomposition method developed by Sarntisart (2020), inequality can be classified into two components, which are horizontal inequality and vertical inequality. Horizontal inequality measures inequality in subpopulations that

share common attributes such as culture, religion, and ethnicity (between subgroups), while vertical inequality measures inequality between individuals or households, which assumes an undifferentiated population (withinsubgroup). The new Gini decomposition method index represents the conflict between income classes and defined subgroups, which might be better than the traditional Gini coefficient, which is suitable for reflecting vertical inequality.

Due to the limitation of data, this study 1) calculates the Gini coefficient from the expenditure side provided by the Household Socio-Economic survey and 2) uses the Gini decomposition method to find the regional Gini coefficient that represents income inequality for Bangkok Metropolitan Region (Bangkok, Samut Prakan, Samut Sakhon, Pathum Thani, Nakhon Pathom, and Nonthaburi) by using the following equation.

$$G_g = 2 * Cov[Y_i, F(Y_i)]/\mu \quad (8)$$

Where

N = population

Y_i = income of individual i

μ = average income

$F(Y_i)$ = cumulative density function at $Y = Y_i$

$$GINI = \sum_{g=1}^G V_g S_g G_g + \frac{1}{2\mu N^2} \sum_{g=1}^G \sum_{i=1}^{N_g} \sum_{k=1}^G \sum_{j=1}^{N_k} |Y_{gi} - Y_{kj}| \quad (9)$$

Where

Y_{gi} = expenditure of individual i of subgroup g

Y_{kj} = expenditure of individual j of subgroup g

$V_g = \frac{N_g}{N}$ = population share of subgroup g

$S_g = \frac{\mu_g N_g}{\mu N}$ = expenditure share of subgroup g

G_g = Gini coefficient of subgroup g

The first part of equation (4) is the sum of the Gini coefficient of each subgroup, weighted by the expenditure share and population share, representing inequality within subgroups. The second part shows inequality between subgroups, calculated from the relative average income of the subgroups.

Bellù & Liberati (2006) noted that apart from the Gini coefficient, there are other measures that are used to measure inequality. First, Atkinson's index is a percentage of total income that must be foregone to have more equal shares of income between households. This measure is popular in welfare-based measures of inequality. The degree of Atkinson's index is determined by society's resistance to inequity. If the society's aversion to inequality is high, the individuals in the community would have an increased willingness to accept smaller incomes for equal distribution. Second, the Hoover index measures the money that wealthy households must redistribute to the below-mean household to increase income inequality in society. A high value means there is high inequality that needs more redistribution. Third is the Theil index and General Entropy (GE) measures; their values range from zero (perfect equality) to infinity (if normalized, the value would be one). The fundamental feature of these measures is that 1) they are fully decomposable, and 2) researchers can choose a parameter that represents a weight to income distribution group distances. This measure is comparable to the Gini coefficient. That is, when income redistribution occurs, the indices alter depending on individual income levels.

Moreover, the decile dispersion ratio is also one of the simple and popular measures in measuring inequality, which represents the ratio of average income or consumption of the top 10 or X percent of the wealthiest household to that of the lowest income household. This ratio compares the two deciles between the richest and the poorest in the income distribution. However, there is some concern about using this ratio, such as outliers or extreme value cases and ignoring information on middle-income distribution (Haughton & Khandker, 2009). In this study, we will focus only on income inequality that is derived from the Gini composition method (Gini coefficient).

3.4 Data

This study uses regional-level data in Thailand from 2011 to 2022 due to the limitation of historical data. In regional data, we classify the data into five regions, including Bangkok & Metropolitan (Bangkok, Samut Prakan, Samut Sakhon, Pathum Thani, Nakhon Pathom, and Nonthaburi), the Central Region, the Northern region, the Southern region, and the Northeastern region. Table 2 shows the list of panel data of the 5 regions in Thailand.

Table 2: List of Data

Variables	Definition	Source
Gini coefficient (GINI)	Gini coefficient. High Gini represents more unequal income distribution.	Household Socio-Economic Survey and National Economic and Social development Council (NESDC)
Housing Price Index (HPI)	Single house price index. High HPI represents high single house price.	Bank of Thailand (BOT)
Gross regional product (GRP)	Gross regional product (value in THB)	National Statistical Office (NSO)
Employment (EMP)	Number of employments	National Statistical Office (NSO)
Policy interest rate (INT)	Bilateral repurchase rate 1 day	Bank of Thailand (BOT)
Consumer Price Index (CPI)	Consumer price index.	Trade Policy and Strategy Office (TPSO)
Education (EDU)	Average year of schooling of household in each region	Household Socio-Economic Survey and National Economic and Social development Council (NESDC)
Private investment indicator (INV)	Newly Construction Area Approved (Thousands of square metres)	Bank of Thailand (BOT)
Consumption Expenditure (CON)	Average consumption expenditure of household in each region	Household Socio-Economic Survey and National Economic and Social development Council (NESDC)

Source: Author's compilation from NESDC, BOT, NSO and TPSO

4. Findings

This study investigates the effect of monetary policy on income inequality across Thailand's regional areas (Bangkok Metropolitan Region, Central Region, Northern Region, Southern Region, and Northeastern Region). The transmission channels include the aggregate income channel, the earning heterogeneity channel, the inflation channel, the interest rate channel, and the housing price channel.

The first step is testing for the unit root test using the Levin-Lin-Chu (LLC). According to Table 3, the LLC result shows that all variables are integrated at level or I(1). If a time series variable is integrated of order greater than or equal to I(2), the computation of the ARDL F-statistic for cointegration becomes unacceptable, and we cannot use the panel ARDL approach to the short-run and long-run relationship between monetary policy and income inequality by using the panel ARDL approach. After testing the unit root test, we tested cointegration using the Pedroni cointegration test (Table 4) and found that all variables (GINI, HPI, GRP, UMP, and D.CPI) were co-integrated.

Table 3: Levin-Lin-Chu Panel Unit Root Test

Variable	Level	Levin-Lin-Chu (LLC) (Without trend)
GINI	Level I(1)	-1.73** (0.03)
HPI	Level I(1)	-5.318*** (0.00)
GRP	Level I(1)	-0.77 (0.22)
	First Diff (Level I(2))	-6.43*** (0.00)
EMP	Level I(1)	-4.02*** (0.00)
D.CPI	Level I(1)	1.37 (0.91)
	First Diff (Level I(2))	-4.77*** (0.00)

Note: a) The number is the adjusted *t* statistics b) The number in parentheses is the *p*-value c) *, **, and *** denote 10, 5, and 1 percent significance levels, respectively

Source: Author's calculations

Table 4: Pedroni Cointegration Test

Model 1: GINI = F (HPI, GRP, EMP, D.CPI)	
Modified Phillips-Perron t	1.99 (0.97)
Phillips-Perron t	-7.54*** (0.00)
Augmented Dickey	-4.97*** (0.00)

Note: a) The number is the *t* statistics b) The number in parentheses is the *p*-value c) *, **, and *** denote 10, 5, and 1 percent significance levels, respectively

Source: Author's calculations

Table 5: Result of ARDL Cointegration Test, FGLS Approach and Seemingly Uncorrelated Regression (SUR)

<i>Y = LOGGINI</i>	Model 1 GINI=F (HPI, GRP, EMP, D.CPI)		Model 2 GINI=F (HPI, GRP, EMP, D.CPI, INT*REGIONS)	
	ARDL	SUR	FGLS	SUR Estimates
	Estimates	Estimates		
<i>LOGHPI</i>	-0.004** (0.02)	-0.11*** (0.00)	-0.06** (0.01)	-0.09*** (0.00)
<i>LOGGRP</i>	-0.003 (0.71)	-0.04*** (0.00)	-0.07*** (0.00)	-0.07*** (0.00)
<i>LOGEMP</i>	-0.09*** (0.00)	-0.04*** (0.00)	-0.01 (0.58)	0.01 (0.79)
<i>D.CPI</i>	-0.14*** (0.01)	0.06 (0.00)	0.61 (0.39)	0.12 (0.27)
<i>INT * REG1</i>			0.02*** (0.00)	0.02*** (0.00)
<i>INT * REG2</i>			0.004 (0.39)	-0.0003 (0.95)
<i>INT * REG3</i>			-0.004 (0.39)	-0.01 (0.29)
<i>INT * REG4</i>			0.004 (0.42)	-0.0004 (0.95)
<i>INT * REG5</i>			0.005 (0.26)	0.002 (0.69)
<i>Y = LOGGRP</i>				
<i>INT</i>		-0.07*** (0.00)		-0.07*** (0.00)
<i>LOGINV</i>		1.25*** (0.00)		1.25*** (0.00)
<i>Y = LOGEMP</i>				
<i>INT</i>		-0.02 (0.53)		-0.02 (0.53)
<i>LOGEDU</i>		-0.04*** (0.00)		-0.04*** (0.00)
<i>Y = LOGHPI</i>				
<i>INT</i>		-0.14*** (0.00)		-0.14*** (0.00)
<i>LOGINV</i>		-0.27*** (0.00)		-0.27*** (0.00)
<i>Y = D.CPI</i>				
<i>INT</i>		-0.01*** (0.00)		-0.01*** (0.00)
<i>LOGCON</i>		-0.02 (0.40)		-0.02 (0.40)
Maximum lag	(1,1)			
Lag order	(1,1,1,1,1)			

$Y = LOGGINI$	Model 1 GINI=F (HPI, GRP, EMP, D.CPI)		Model 2 GINI=F (HPI, GRP, EMP, D.CPI, INT*REGIONS)	
	ARDL Estimates	SUR Estimates	FGLS	SUR Estimates
	Error correction coefficient			R-squared
ECM_{t-1}	-0.81			
Log Likelihood/Wald chi squared	174.98		665	
$LOGGRP$		0.93		0.93
$LOGEMP$		0.20		0.20
$LOGHPI$		0.69		0.69
$D.CPI$		0.24		0.24
$LOGGINI$		0.60		0.60

Note: a) *, **, and *** denote 10, 5, and 1 percent significance levels, respectively

Source: Author's calculations

From Table 5, this study applies the panel ARDL, FGLS, and SUR methods to investigate whether monetary policy affects income inequality through various transmission channels. First, we employed the panel ARDL model to examine short-and long-run relationships. However, other factors may influence the transmission channel variables, which might be an issue related to omitted variable bias, so we use the SUR, allowing the simultaneous estimation of multiple regression equations. This method may mitigate omitted variable bias issues and improve parameter estimates' efficiency. It can also confirm that monetary policy indeed affects the transmission channels through which income inequality is impacted. We divided the model into two forms. The first model does not include the interaction variable between the monetary policy rate and dummy regions. By incorporating the interaction variable, we can analyze the differing impacts of the policy interest rate on income inequality across various regions.

The results from the SUR analysis indicate that the transmission channels of monetary policy through the transmission channels (variables GRP, EMP, and CPI) are significant. This confirms that these channels are indeed affected by the policy interest rate. However, EMP, which represents the earning heterogeneity channel, is insignificant. In addition, the results obtained from FGLS and SUR estimates were consistent, confirming our results are robust. This consistency indicates that our results are reliable, even when accounting for heteroskedasticity and the correlations in the error terms.

4.1 Aggregate income channel

The GRP variable shows a negative relationship between GRP and income inequality, significant at a 1% level. The coefficient in model 1 is -0.04, implying that a 1% increase in GRP lowers income inequality by 0.04%. In addition, in model 2, where we add the interaction term, the GRP variable is still negatively significant, and the coefficient is -0.07. As we confirm the channel that changes in monetary policy can affect through the GRP channel, we can imply that an expansionary monetary policy increases individual and aggregate income in regional areas, resulting in higher GRP, which reduces income inequality. This result contradicts the results in developed

countries, which explain that expansionary monetary policy increases income inequality. Households with low-end distribution income rely on transfer income, while those at the average rely on labour wages, and those at the top rely on business and capital revenue. Therefore, decreasing the policy rate leads to higher GRP, which would bring more benefits to wealthy households than lower ones. However, our result is consistent with the findings of Tapasanan & Ronaparp (2020) and Ruankham & Sethapramote (2023), which use the country-level model in Thailand. Tapasanan & Ronaparp (2020) also noted that the negative relationship may be because economic growth is associated with international trade and investment, which reduces poverty and inequality in the case of Thailand.

4.2 Housing price channel

This channel is an additional portfolio channel that we add to our model. According to the theoretical framework, increasing asset prices associated with expansionary monetary policy benefits wealthy households who own the bulk of financial assets, earning from dividends and capital gain (wealth effect). At the same time, Lenza & Slacalek (2024) noted that monetary easing could change rental prices, which also affects the income distribution (income effect). Booming in the housing market due to expansionary monetary policy would be one of the crucial barriers for vulnerable groups or low-income groups in buying a house (Bonnet et al., 2014). This leads to widening the gap between the rich and the poor and increased income inequality. Our results from regional-level data in Thailand contradict the framework and previous literature in the case of SEACEN-8 countries (Punzi, 2020). The HPI index shows negative results in both Model 1 and Model 2, which means a 1% increase in housing prices led to mitigating the regional income inequality by 0.11% and 0.09%, respectively. However, according to the International Monetary Fund's (IMF) paper (Albuquerque et al., 2024), the easing of monetary policy induces an increase in housing prices but a decrease in rental prices in the case of the United States. This is because people who can afford a new house change from rent to buy, so the demand for rent decreases. Therefore, the lower-income groups that mostly do not have access to buy a new house would benefit from a reduced rental rate, mitigating income inequality, which is consistent with Battistini et al. (2022).

4.3 Earning heterogeneity channel

Expansionary monetary policy affects economic activities and results from changes in employment and non-financial income. For non-financial income, the lower-end distribution household's primary income source is labour earnings, which are represented by real wages. Easing monetary policy reduces income inequality due to increasing the low-income household's primary source of income. For employment, Galli & van der Hoeven (2001) indicated that it is one of the transmission channels through which monetary policy affects income distribution. Restrictive monetary policy hurts unemployment and worsens income inequality because firing and hiring costs for skilled workers are relatively greater than those of low-skilled workers, which are sensitively affected by the employment rate and working hours. According to the results, the employment variable is not significant in only Model 1, but in Model 2, when we add the interaction term in our model, it is significant. In testing the relationship between monetary policy rate and employment in the SUR estimates, it shows an insignificant relationship between employment and monetary policy rate, so we cannot confirm that the employment channel serves as a transmission mechanism through which changes in monetary policy directly impact income inequality. However, according to the ARDL approach, it shows a significance at a 1% level with a negative

relationship, which confirms the long-run relationship between the increase in employment and regional income inequality, which means increasing employment leads to an enhanced income inequality problem. The surge in employment leads to benefits for low-income households and mitigates regional income inequality. A 1% increase in employment leads to a reduced regional income inequality of 0.09% in Model 1 (ARDL). This ARDL finding is consistent with the framework and previous studies such as Inui et al. (2017) and Punzi (2020).

4.4 Interest rate channel

The interaction term in Model 2 from the SUR and FGLS estimates shows a significant level of 1% for only Bangkok Metropolitan Region dummy variable. This means that when interest rates increase, income inequality in Bangkok Metropolitan Region also increases compared to other regions. This indicates that this area is more sensitive to interest rate changes than other regions. Consequently, changes in the policy interest rate have the most significant impact on households in Bangkok Metropolitan Region compared to other regions. The positive sign of the coefficient indicates that decreasing interest rates from easing monetary policy measures reduces Bangkok Metropolitan Region's income inequality. This pinpoints that Bangkok Metropolitan Region may be more sensitive to interest rate changes than other regions. This may be because of economic concentration that concentrates businesses and investment activities. The population in these areas has high levels of consumption and investment, so changes in interest rates can affect spending and investment behaviors in this area. In addition, households would benefit or lose depending on their holdings and liabilities, which are directly affected by monetary policy schemes. Easing monetary policy benefits those who are net borrowers with long-term debts because it reduces interest payments for households with net outstanding debt, which mostly represents the low-end distribution income group (Ampudia et al., 2018). This may imply that Bangkok Metropolitan Region's populations have more shares in liabilities with financial institutions than others. A 1% decrease in the policy interest rate decreases regional income inequality by around 0.02%. The result is consistent with a country-level model in Thailand that also represents a positive relationship between interest rate and income inequality in the case of Ruankham & Sethapramote (2023).

Moreover, according to the ARDL approach, we test the cointegration tests, as presented in Table 4, indicating that the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test are significant, suggesting the presence of a long-run relationship among the variables. The results of the ARDL model show that CPI, EMP, and HPI are significant, confirming the long-run relationship between those variables and income inequality. We also test the short-run dynamics using the error correction model (ECM) for model 1. The result of the error correction estimates in the case of regional areas in Thailand is shown in Table 5. The coefficient of the ECM term represents the speed of the adjustment process to the long-run equilibrium path. The ECM term indicates a negative sign and is statistically significant. The coefficient of the ECM term is -0.8, which implies that the deviations in the short run towards the long run are corrected by 80% per year. This means it would take more than one year to attain a full convergence process in any shock to regional income inequality in Thailand.

In sum, the aggregate income channel, housing price channel, and interest rate are the transmission channels that propagate monetary policy to regional income inequality in Thailand. The study confirms that easing monetary policy stimulates the economy through GDP, HPI, and INT, which helps reduce regional income inequality. Bangkok Metropolitan Region are the most elastic regions to change in monetary policy compared to other regions. The results align with findings from Feldkircher & Kakamu

(2022), who observed that monetary policy also affects regional income inequality in Japan, with expansionary monetary policies reducing income disparities by stimulating economic activity through lower interest rates. While the case of Europe shows that easing monetary policy helps reduce regional inequalities, the transmission channels and household characteristics differ. De Groot et al. (2020) found that poorer regions exhibit stronger and more persistent responses to monetary policy shocks, whereas in Thailand, Bangkok Metropolitan Region, which are not poor regions, respond more effectively to monetary policy changes.

5. Conclusion and Policy Implications

This paper uses the regional-level data in Thailand to investigate how monetary policy is transmitted to regional income inequality. We construct a yearly series of regional income inequality measured by the expenditure of households from the household socio-economic survey from 2011 to 2022 and estimate their response to monetary policy through various transmissions, including aggregate income, housing price, earning heterogeneity, interest rate, and inflation channel by using ARDL, FLGS, and the SUR estimates.

The results confirm that monetary policy decisions affect regional income inequality in Thailand through the housing price channel, the aggregate income channel, and the interest rate channel. Expansionary monetary measures that aim to boost economic activities can mitigate the inequality problem through higher gross regional product. Stimulating the economy is associated with increasing economic activities and investment, leading to higher economic growth that may help reduce inequality. Therefore, increasing regional growth can reduce the gap between the rich and poor in regional areas. For the housing price channel, it also shows a negative relationship, meaning that the low-income household may benefit from reducing the rental price. In addition, the results pinpoint that different regions have different responses to the change in monetary policy. Bangkok Metropolitan Region are more elastic to the change in interest rate than other regions, and reducing interest rates leads to a decrease in income inequality in Bangkok Metropolitan Region. Our findings should have policy implications that focus on improving access to financial resources in other regions, enhancing financial infrastructure, and fostering local economic development. Additionally, increasing financial literacy and investing in skill development programs can help reduce regional income inequality.

Our findings point out that the central bank should recognize the effect of monetary policy on regional income inequality. Focusing on stabilizing the price and managing economic fluctuations, which is the aim of monetary policy, can enhance the well-being of the population and income disparities at the regional and country level. Firstly, reducing interest rates or implementing measures that lower the cost of borrowing to buy a house may seem to reduce inequality. This study confirms that such policies can lessen the obstacle and make it easier for households to access funds. This, in turn, can lower rental prices, benefiting low-income groups who primarily rent their homes. Secondly, stimulating the economy not only leads to an increase in GRP in the regional area but also positively impacts inequality. This is because all households benefit from increased economic activities resulting from economic expansion, which in turn reduces inequality. Thirdly, reducing interest rates directly impacts income disparities in Bangkok Metropolitan Region because the concentration of business activities leads to more sensitivity and responsiveness to monetary policy measures. This study is one of various studies that highlight concerns that monetary policy may

have a differential impact on regional income inequality and may vary across different regions and operate through distinct channels in each area. Our finding may raise awareness of the need to tailor monetary policy to ensure that households in different regions benefit from monetary measures equitably.

Additionally, the study's significant limitation is the availability of long historical data, and it is not possible to conduct country-level models using time series data comprehensively, which may affect the accuracy and reliability of the study's results on a broader scale. For future research, it is beneficial to explore the effects of macroprudential measures on income and wealth inequality at both the country and regional levels because macroprudential measures may have direct redistributive effects on inequality. This may provide more in-depth details of the impacts of policy measures on inequality across different regions and households.

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