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RESEARCH PAPER

Finding Financing Risk Factors in Indonesian Islamic Banks: A Geographically Weighted Regression Approach

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Abstract
This study aimed to measure Non-Performing Financing (NPF) factors through Gross Regional Domestic Product (GRDP), unemployment rate, office network, consumptive financing, and COVID-19 cases. Cross-section data in 34 Indonesian provinces were analyzed using Geographically Weighted Regression (GWR) through global regression confirmation. The results showed differences between the GWR and global regression. All exogenous variables have spatial variability to endogenous variables. This resulted in variations in local models influencing NPF, including in DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, Bali, and West Nusa Tenggara Provinces. Additionally, this study has implications for bankers in mitigating credit risk by maintaining the adequacy ratio of funds and tightening the verification of prospective debtors. Bankers should also restructure financing, monitor portfolio performance, and build digital infrastructure in each regional office by considering the dynamics in the provinces. In addition, the province's representative of the Financial Services Authority and Central Bank offices must coordinate directly supervising Islamic banks in the region.
Keywords: Financial Intermediaries, Geographically Weighted Regression, Islamic Bank, Regional Growth, Risk Assessment.
JEL Classifications: G21, R11, C31.

1. Introduction
The spread of Coronavirus Disease 2019 (COVID-19) has impacted economic and financial aspects globally because handling the disease requires each country to implement social restrictions nationally and transnationally (Aum et al., 2021; Sharma and Mahendru, 2020). Although the policies have suppressed the spread, all countries received strong shocks to the economic and financial sectors (Atalan, 2020; Cozzi et al., 2020; Nicola et al., 2020; Rabbani et al., 2021; Tisdell, 2020).

Furthermore, COVID-19 promoted a decrease in demand and supply of various products and services, resulting in Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) (Bekaert et al., 2020; del Rio-Chanona et al., 2020; Hassan, Rabbani, et al., 2020). It caused a decline and change in consumption patterns and a decrease in performance for banking sector financing (Bilgin et al., 2021; Christelis et al., 2020; Deloitte, 2020). Social restriction policies also complicate production activities, resulting in declining economic growth in various regions (Vet et al., 2021). Most companies must lay off employees to reduce operational burdens, contributing to 33 million people or 6.8% of global unemployment (International Labour Organisation, 2021). Additionally, the global poverty rate has increased to 150 million people (Economic Commission for Latin America and the Caribbean, 2020; Laborde et al., 2021; Sumner et al., 2020; UNICEF et al., 2021).

The impact of COVID-19 disrupts the conventional economic system and affects the stability of Islamic economic performance, though it is considered a solution to global economic problems (Agustin et al., 2021; Fakhrunnas et al., 2021; Fernandes, 2020; Shafiq, 2020; Zaman, 2013). The leading indicators of the Islamic economy represented by the performance of Islamic banking have also decreased due to VUCA-world conditions (Kasanah et al., 2022). Consequently, Islamic banks have the potential to experience inefficient financial performance (Mufraini et al., 2021; Rizwan et al., 2021). Although Islamic banks have solid fundamentals and consistently contribute to global financial assets of 70% or worth US$ 2,349 billion (Mohamed and Ahmed, 2021), they cannot avoid the shock caused by COVID-19 (Mateev et al., 2021).

Indonesia is the largest Muslim country worldwide, with 87.2% of 270 million population being Muslim (Central Intelligence Agency, 2019; Hefner, 2021). The country occupies the second vein in the Islamic Finance Country Index and the Most Developed Country in Islamic Finance in 2020 based on demographics, education, research, compliance, and regulatory certainty (Edbiz Consulting, 2020; Mohamed et al., 2020). However, the acquisition of Indonesian Islamic banking assets has not contributed globally (Mohamed and Ahmed, 2021). This is due to the increased risk of Islamic banking financing during the pandemic, which disrupts financial performance (Hassan et al., 2021; Jobst and Solé, 2020). Furthermore, Islamic banking is an intermediary institution highly dependent on economic stability (Firmansyah, 2015; Khasanah and Wicaksono, 2021). This

means that an economic crisis would have a multiplier effect on the economic and financial sectors (BPS-Statistics Indonesia, 2022). Moreover, the spread of COVID-19 has caused a reduction in Gross Domestic Product (GDP) to -5.32%, promoting a 7.07% increase in the unemployment rate. Another impact is the negative fluctuating trend in the financing and Non-Performing Financing (NPF) sectors (Fakhrunnas et al., 2021; Goodell, 2020; Kuzucu and Kuzucu, 2019; Mansour et al., 2021). The government has issued a stimulus policy to restructure financing to Financial Institutions (National Economic Stimulus as Countercyclical Policy Impact of Coronavirus Disease Spread 2019, 2020; Financial Services Authority, 2020; Sukmana et al., 2020; Warjiyo, 2020). However, Islamic banks have not reduced the NPF level because the Indonesian economy has received stronger shocks than other Muslim countries such as Bahrain, Brunei, Kuwait, Malaysia, Pakistan, Saudi Arabia, Turkey, and the UAE (Mansour et al., 2021). The risk of financing Islamic banks cannot be ignored because it can potentially repeat a systemic crisis (Bagus Wiranatakusuma et al., 2020). Islamic banks have a good image as a financing solution with sharia values (Muhammad and Triharyono, 2019), so if Islamic banks go bankrupt because they are unable to control risks (Ahmed, 2009), it has the potential to have the effect of decreasing customer trust in the bank as a whole and creating a bank run that encourages a monetary crisis (Farooq and Zaheer, 2015; Jan et al., 2019).

Economic instability has increased financing risks in NPF through customer delays in payments (Ahmed and Khan, 2007; Damanhur et al., 2018; Mohd Isa and Abdul Rashid, 2018; Priyadi et al., 2021). External factors through decreased GDP increased unemployment, and uncertain business climate to customer moral hazard could increase financing risk for banks (Effendi and Yuniarti, 2018; Habibi and Rusgianto, 2021; Jassaud and Kang, 2015; Mutawali et al., 2019; Parven, 2011; Santosa et al., 2020; Trinugroho et al., 2021; Zheng et al., 2019). Internal factors also have a role in managing financing risks through the efficiency of intermediary functions and service accessibility in the availability of office networks (Edaich and Dymek, 2020; Havidz and Setiawan, 2015; Maulidar and Majid, 2020). However, strict regulations in financing verification by measuring the customers' capacity and ability are more dominant in controlling NPF in Islamic banks (Omar, 2020), and it manage financing risks appropriately (Abbas and Ali, 2019; Firmansyah, 2015; Hassan, Shaikh, et al., 2020; Khanam and Ullah, 2014; Priyadi et al., 2021). Nicola et al. (2020) and Nugroho et al.

(2020) found that COVID-19 is the primary source of risks in the banking sector through social distancing, self-isolation, and travel restrictions. The disease has also promoted the condition of VUCA in the financial sector, enabling banks to determine the best model for mitigating financing risks (Alabdullah et al., 2020; Edaich and Dymek, 2020). When the bank takes too long to adjust to conditions, this impacts financing risks (Adler et al., 2022; Miah et al., 2021). In addition, a poor understanding of financing risks can threaten bank performance through declining profits and revenues (Ebenezer and Omar, 2016; Rehman et al., 2019). The occurrence of defaults can compromise the health of banks through mishandling in managing financing risks (Africa, 2016; Tejo and Hanggraeni, 2020).

Asnawi et al. (2020) and Wicaksono (2022) found that Islamic bank performance is driven by external and internal factors but must consider geographical aspects in mapping a problem (Abeyratne and Cooray, 2017; Ludovic et al., 2020; Wang and Guan, 2017). The geography model is appropriately implemented in the archipelago area (Z. L. Chen et al., 2020; Danon et al., 2020; Gatto et al., 2020; Ludovic et al., 2020). Indonesia is geographically an archipelagic country with 17,504 islands in 34 provinces (Estiningtyas et al., 2021). Therefore, each region requires a specific approach to provide information appropriately (Fauzan et al., 2020; Grydehøj and Hayward, 2014; Mahendradhata et al., 2017; A. Mufraini et al., 2020). The global regression approach or multiple regression model measures a phenomenon without considering the weighting aspects of each location (Chen and Truong, 2012; Fotheringham et al., 2002). Moreover, making decisions based on a single model implemented on the entire data set makes it possible to create gaps in real conditions (Kang and Zhao, 2020). In addition, global assumptions can obscure the geographical role and complexity of phenomena that arise in each region with different characteristics (Chen and Truong, 2012). In contrast, the Geographically Weighted Regression (GWR) approach effectively improves the analysis accuracy in global regression by adding local spatial weights for each location (Permai et al., 2021). The approach solves the problems of spatial heterogeneity and improper autocorrelation in models (Fan et al., 2000; Huang et al., 2010; Tabuchi and Thisse, 2011; Wei et al., 2019). It makes the models approximate phenomena in each geographic location (Chen and Strathearn, 2020; Patterson et al., 2020; Zhang, 2014), and it creates different models and equations in each region depending on the phenomenon in the area

(Permai et al., 2021). In addition, this method has not been widely used to evaluate a policy because most of the research is not on the archipelago. Consequently, it ignores the geographic approach in measuring the performance of Islamic Banking (Wicaksono, 2022).

Most studies focused on global proximity in measuring the risk of Islamic bank financing by involving various methods and variables (Abbas and Ali, 2021; Ali et al., 2021; Kabir et al., 2015; Masood et al., 2012). Priyadi et al. (2021) performed tests with the Auto Regressive Distributed Lag (ARDL) approach for short- and long-term relationship investigations on NPF. Moreover, Bahrul Ilmi (2018) and Misman et al. (2015) used a multiple regression approach to investigate factors affecting global financing risks in Islamic banks in Indonesia and Malaysia. The study used financing variables, labor relationship development, and banking ownership status. Warninda et al. (2019) applied a random effect regression model approach with white diagonal robust standard error and Fama - Macbeth regression. The study aimed to measure the strongest impact globally between *mudarabah* and *musharakah* financing on the risks of Islamic bank financing in the Middle East, South Asia, and Southeast Asia regions. Furthermore, Hidayat et al. (2021) employed a t-test approach and a regression methods panel to evaluate the risk trade-off process. The study compared financing risks to Islamic and conventional banks in the Gulf Cooperation Council (GCC) area. However, there needs to be more literature on measuring the potential financing risks of Islamic banks locally with a spatial approach in the archipelago. Although the global regression approach is often used for decision-making in risk mitigation of Islamic banks, the different characteristics between one region and another are neglected, so analysis and conclusions can potentially become biased (Kang and Zhao, 2020). In addition, this study adopts a Geographic Information System (GIS) approach to map the level of significance in the models formed in each region so that the risk mitigation process can be carried out precisely based on the phenomena that occur in each region instead of generalizing one model in all different regions.

This study aims to measure Islamic bank financing risk factors through the variables of Gross Regional Domestic Product (GRDP), unemployment rate, office network, consumptive financing, and COVID-19 cases. In addition, this study investigated the spatial role of exogenous variables against endogenous variables in the model, which has a relationship of activity between spaces in each province. It verified the differences in the results of global regression and GWR analysis

through a geographical approach based on the weight values of each region through latitude and longitude. Then, predict the variety of models locally and map the significance of spatial models in each province which is useful for providing comprehensive input to Islamic banks and authorities in the post-pandemic risk mitigation process.

2. Literature Review

COVID-19 has made Islamic banks as intermediary institutions more vulnerable to financing risks. The banks must tighten the financing verification process through checks on financial history and customer background (Akram and Rahman, 2018), because increased financing risk impacts liquidity and financial performance (Alzoubi, 2017; Hosen et al., 2021). When the policies taken cannot anticipate the condition of VUCA, banks are predicted to experience a trust crisis from customers. This could cause a bank run, with a systemic impact on various crises in the banking sector (Anginer and Demirguc-Kunt, 2018; Masiukiewicz and Howzan, 2015; Schoors et al., 2019). COVID-19 has caused many large companies to experience defaults and bankruptcies. Moreover, Micro, Small, and Medium Enterprises (MSMEs) that faced the 1998 and 2008 crises have also experienced shocks due to the government's social and operational restriction regulations (Cepel et al., 2020; Fairlie, 2020; Hamburg, 2021). This means that banks must be ready to face default by counterparties through various policies to reduce financing risks during a pandemic (Habibi and Rusgianto, 2021; Hassan, Rabbani, et al., 2020; Maulidar and Majid, 2020).

El-Chaarani et al. (2022) explained significant differences between Islamic and conventional banks in the GCC region during the pandemic. Conventional banks have a better ability to manage financing risks, though the inflation rate and NPF are negatively correlated with financial performance. In contrast, Islamic banks declined after the pandemic (Fakhrunnas et al., 2021; Hassan, Rabbani, et al., 2020; Mateev et al., 2021). Hassan et al. (2022) explained that the pandemic had slowed the growth of Islamic commercial finance oriented toward maximizing profits. The pandemic has created more opportunities for Islamic social finance through the increasingly widespread use of multilateral institutions in helping the community. The decline in Islamic banking performance is also due to insufficient government support. Banks have the potential to experience liquidity problems when people shift to cash orientation amid the pandemic (Koechlein, 2021; Omar,

2020). Although conventional banks are also experiencing shock due to COVID-19, most of the operational funds of government agencies still utilize conventional bank services (Bassett et al., 2020), it indicates fund adequacy is still maintained (Adesina and Olatise, 2019; A. Mufraini et al., 2020; The Central Bank of Bangladesh, 2022).

The Islamic banking industry was one alternative solution for economic recovery after the 2008 crisis before the COVID-19 pandemic (Alqahtani and Mayes, 2017; Ascarya, 2013), it is because Islamic banks offer financing by eliminating interest in each transaction and applying an approach of trust, compliance, and openness based on Islamic values (Kılıç and Çanakcı, 2022). The banks also used underlying assets based on Profit and Loss Sharing (PLS) (Hussien et al., 2019; Mahdzan et al., 2017; Omar, 2020). This method promotes mutually beneficial contracts for the giver and recipient of funds (Ezeh and Nkamnebe, 2018; Kaabachi and Obeid, 2016; Ozsoy, 2016). Applying interest in conventional bank financing has encouraged the emergence of various economic crises (Fiore and Uhlig, 2015; Ozturk and Sozdemir, 2015). For instance, COVID-19 disrupts various risks systemically (Ivanov, 2021; Kilpatrick and Barter, 2020), with Islamic banks also receiving the same impact as conventional banks due to the pandemic (Barua and Barua, 2021; Jackson et al., 2020)

Islamic banks have tightened the provision of financing and encouraged the government to implement various stimuli to reduce financing risks (Shahchera, 2022). Moreover, the government should conduct a policy rate cut to facilitate banking services, household assistance, workers, MSMEs, and foreign investors to maintain economic and financial stability (Zulfikar, 2019). Furthermore, policies are taken to avoid debt traps in economic sectors because economic growth strongly correlates with the Islamic bank financing risk (Effendi and Yuniarti, 2018; Habibi and Rusgianto, 2021; Jassaud and Kang, 2015; Mutawali et al., 2019). Islamic banks have verified their activities twice as strictly as conventional banks by considering normative rules and Islamic principles (Karim and Shetu, 2020; Khanam and Ullah, 2014). Even, the banks have consistently applied Islamic principles by not providing financing for something *riba*, *maysir*, and *gharar* (Rabbani et al., 2021). The application of Islamic principles in the financial industry is increasingly in demand, and many Islamic financial products and services have emerged worldwide, including Islamic insurance, investment, capital markets, and mutual funds (Alsharari and Alhmoud, 2019; Šeho et al., 2020).

The implementation of risk management is an obligation for the financial industry. The government must direct central banks and financial services authority institutions to implement risk management in each bank because banking is inseparable from problems related to socio-demographic, asymmetric information, moral hazard, and economic, political, and cultural that can increase financing risk (Hassan et al., 2021; Lončarski and Marinč, 2020; Rafay et al., 2020). After the spread of COVID-19, the banking industry has experienced shocks that have increased liquidity and financing risks (Karim et al., 2021; Mustafa, 2020). Therefore, banks need to manage risks properly to avoid losses due to the multiplier effect after the pandemic (Baret et al., 2020). This study adopted the risk management theory as an approach to the middle range theory. The aim was to connect the theory of financial intermediation by developing a theory of location.

Risk management theory contributes to the risk reduction of bank profits based on failure to fulfill debtor obligations (Tursoy, 2018). Banks have conducted a feasibility assessment verification on the provision of financing. However, they cannot ignore macroeconomic factors, activities, and internal banking conditions (Bojinov, 2016). Implementing financing risk mitigation aims to determine the risks bank face in the future, so it helps the bank determine the proportional financing (Liu and Huang, 2022). The risk management process in Islamic banks also adopts shariah compliance implementation, and they prioritize the role of the Shariah Supervisory Board and fatwas of the Ulema Council (Setyowati et al., 2019). The application of shariah compliance elaborates between Islamic norms and values to the operating system in the banking industry by abandoning the practice of *riba* and promoting *maqashid* shariah (Hudaefi and Badeges, 2022; Ullah et al., 2023).

Mitigating financing risks process in Islamic banks considers geographical conditions at branch offices (Asnawi et al., 2020; A. Mufraini et al., 2020; Wicaksono, 2022), because each region has the potential to pose different risks to a business (Snieska et al., 2019). Moreover, the location theory states the importance of involving location in mapping risks to optimize decisions to maximize profits and avoid potential losses (Dubé et al., 2016). In addition, the geography approach explains the differences in activity in each observation area based on the resources and character of each region to explain the problems that are missed in the traditional approach of global analysis by showing the potential

for local variation in the observed area (N. Chen et al., 2017). The geography approach also uses GIS to describe the regularity of the observation location on spatial properties and processes (Sulekan and Syed Jamaludin, 2020), ensuring that the analysis results are oriented towards each region.

GIS is a technology used to accurately analyze geographical aspects spatially through remote sensing (Lee and Jang, 2017). In addition, this analysis will present mapping to help make decisions and solve problems to manage risks for business units (Jebur, 2021). Then, GIS can be used in floating financial institution strategy planning (Maximenko and Maximenko, 2021). It can describe risks more clearly by considering geographical aspects. It makes it easier for banks to understand potential risks before investing, financing, or providing loans in various business sectors. The GIS approach can also provide extensive information related to health, habit, demand, purchasing, and economic conditions (Khan and Yesmin, 2016; Weber, 2018) so that potential risks in financing can be controlled.

3. Methodology and Data

This study aimed to measure Islamic bank financing risk factors based on the GWR approach through economic growth, bank intermediary, and COVID-19. The variables were represented by exogenous variables, including GRDP, unemployment rate, office network, consumptive financing, COVID-19 Deaths, and Islamic Bank NPF.

Table 1. Operational Variables

Variable	Symbol	Description	Source
Exogenous Variable			
Gross Regional Domestic Product	GRDP	GRDP Rate in each Province	BPS
Unemployment Rate	Unemployment	Unemployment Rate in each Province	BPS
Office Network	Office Network	Number of office networks in each province	OJK
Consumptive Financing	Consumptive Financing	Amount of Islamic Banking Consumption Financing in each Province	OJK
COVID-19 Deaths	COVID-19	Number of COVID-19 Deaths in Each Province	COVID-19 Task Force
Endogenous Variable			
Non-Performing Financing	NPF	Amount of Islamic Banking NPFs in each Province	OJK

Source: Research finding.
Note: Central Statistics Agency (BPS), Financial Services Authority (OJK)

Cross-section data in 34 provinces in 2021 were obtained from the Central Statistics Agency (BPS), the COVID-19 Task Force, and the Financial Services Authority (OJK). In the first phase, descriptive statistical analysis was conducted to organize, summarize, and understand data measurements through an overview of the relationships between variables in a sample (Shi and McLarty, 2009; Tzeng, 2011). This testing is critical in analyzing the differences in character in the sample influencing the initial decision (Loeb et al., 2017; Thompson, 2009). Furthermore, the Classical Assumption test was conducted by involving the Normality, Heteroskedasticity, and Multicollinearity Test approaches through Jarque-Bera, Breusch-Pagan Test values and Variance Inflation Factor (VIF) values (Khatun, 2021; Kwak and Park, 2019; Li and Yao, 2019; Shrestha, 2020; Stehlík et al., 2014). The Classical Assumption test results may indicate the presence of spatial influences through nominal values on the equations in the model (Kala et al., 2017; Leung et al., 2000). In the third stage, a global regression model tested the relationship between exogenous and endogenous variables by estimating the following equations (Susanti, 2018).

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_p x_p + \varepsilon \quad (1)$$

where y is an endogenous variable, $\beta_0, \beta_1, \beta_2, \beta_p$ are model parameter, x_1, x_2, x_p are exogenous variables, and ε is an error. With the observation of several n, the model to i is as follows (Lutfiani et al., 2019):

$$y_i = \beta_0 + \sum_{k=1}^{p} \beta_k x_{ik} + \varepsilon_i \quad (2)$$

where i is the observation to i, β_k is the coefficient of the exogenous variable to k, x_{ik} is the value of the exogenous variable to k at the point of the observation location to i, and ε_i is an error in the location to i. In the global regression model, the relationship between exogenous and endogenous variables was considered the same (Duarte-Cunha et al., 2016; Kuhn and Johnson, 2013). This is because it does not involve the approach and weighting of geographical locations in measurement. The global regression model placed linearity in its parameter, assuming the average value in error to be zero and constant (Fahrmeir et al., 2013; Gujarati and Porter, 2009). A comprehensive analysis necessitated an assessment based on the geographical location of the study sample (Fotheringham et al., 2002). In the fourth stage, the GWR model was tested to develop a regression analysis by adopting a geographical approach. This approach was based on non-parametric regression through weighting values in each region. It was based on latitude and longitude coordinates, where each observation in the sample had different weights and coefficient values as modeled in the following GWR equation (Jetz et al., 2005; Lutfiani et al., 2019; Páez and Wheeler, 2009; Permai et al., 2021).

$$y_i = \beta_0 (u_i, v_i) + \sum_{k=1}^{p} \beta_k (u_i, v_i) x_{ik} + \varepsilon_i \quad (3)$$

where y_i is the value of the exogenous variable for the location to i, (u_i, v_i) is the geographical coordinates in the form of latitude and longitude at the location to i, $\beta_0 (u_i, v_i)$ is the interception of the observation location to i, and $\beta_k (u_i, v_i)$ is the value of the coefficient of the exogenous variable to k at a location to i (Fotheringham et al., 2002). Additionally, the Cross Validation (CV) method was used to determine the Optimum Bandwidth value through the following equation (Ardianti et al., 2021).

$$CV = \sum_{i=1}^{n} [y_i - \tilde{y}_{\neq i}(b)] \quad (4)$$

where $\tilde{y}_{\neq i}$ is the estimating value of the y_i in the observation of the location to i and b is the optimum bandwidth, the radius of a pattern in the region, which is

essential for balancing weighting. The determination of CV as an optimum bandwidth model was based on its function to minimize bandwidth values. When the value is large, it could cause bias in the Global Regression analysis (Cho et al., 2010; Farber and Páez, 2007). Spatial weighting was also conducted through parameter estimation based on adaptive gaussian kernels through an adaptive ability. The aim was to adjust conditions at the point of the sample's location to explain the results of spatial calculations with the estimation of adaptive gaussian kernels equations as follows (Fotheringham et al., 2002; Permai et al., 2021).

$$W_{ij} = \exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{b_i}\right)^2\right] \quad (5)$$

where W is a weighting, b is Bandwidth adaptive in assigning locations to I, and d_{ij} is a Euclid between locations. A Goodness of Fit analysis was conducted to determine the difference between Global Regression and GWR. The best model was determined by comparing the Calculated F value against the F-table on the Residual GWR value. F-count > F-table implies a difference between the Global Regression and GWR models. This indicates that the GWR model is the best (Fotheringham et al., 2002; Nur Edayu and Syerrina, 2018).

The next stage analyzed the geographical variability tests of local coefficients to determine the spatial relationships between exogenous and endogen variables through the difference in criterion. In this case, a negative value indicated that the variable had spatial heterogeneity and vice versa (Fotheringham et al., 2002). The results of each coefficient value were shown by spatial mapping through an earth map.

4. Results and Discussion

In the first stage, descriptive statistical data analysis was conducted to determine each variable's characteristics, including the mean, maximum, minimum, and standard deviation values. The data comprised 34 observations carried out in 2021. This analysis focused on the dynamics in GRDP, unemployment, office networks, COVID-19, consumptive financing, and NPF.

Table 2. Descriptive Statistic

Variable	Minimum	Mean	Maximum	Std. Dev.
GRDP	-2.47	4.17	16.40	3.58
Unemployment	3.01	5.49	9.91	1.81
Office Network	0.00	72.88	379.00	99.52
COVID-19	264.00	4237.82	30287.00	7307.43
Consumptive Financing	0.00	3555.75	20850.43	5228.54
NPF	0.00	194.81	1839.85	386.82

Source: Research finding, using Eviews.

The analysis showed that GRDP had an average value of 4.17 in each province in Indonesia. This means that the pandemic's regional economic growth is growing by 4.17%. However, it must face an unemployment rate of 3.01 – 9.91% and 4,237 cases of COVID-19 deaths in each province. Indonesia has accelerated the post-pandemic economic recovery process (International Monetary Fund, 2022), but it is struggling with the increase in NPF value to 1.83 trillion rupiahs or 194 billion rupiahs in each province. The movement in the NPF value was also driven by the consumptive financing of 20.85 trillion rupiahs. The supervision and assessment controls involved 72 office networks of Islamic banks in each province. Therefore, there needs to be special attention to the increasingly high consumptive financing with the office networks that are not comparable because they do not only function as information and service centers for customers but also supervise financing (Rönnqvist and Sarlin, 2016).

Weak economic conditions affect the stability of bank financing in a region (Crocco et al., 2014; Lee and Brown, 2017). This implies the need to carry out strict supervision for every financing activity. Since Indonesia has a heterogeneous dynamic as an archipelagic country, policy-making should consider regional aspects because each region has its characteristics and phenomena (Fauzan et al., 2020; Mufraini et al., 2020). Islamic banking should also respond to financing risks in GRDP, unemployment, availability of office networks, COVID-19, and the level of consumptive financing to prevent the increase in NPF value.

Table 3. Regression Diagnostic

Diagnostic	Indicator	Value	Prob.	Note
Normality Test	Jarque-Bera	17.66	0.00	Not Significant
Heteroskedasticity Test	Breusch-Pagan	66.07	0.00	Not Significant
Multicollinearity	VIF	Condition Number		Not Significant
		16.52		Not Significant

Source: Research finding, using GeoDa.

The results of the regression diagnostic on the normality test through jarque-bera values showed that the model is not normal based on probability values of 0.00 or $p< 0.05$ (Khatun, 2021). Similarly, the results of the heteroskedasticity test through breusch-pagan values showed the presence of heteroskedasticity with a probability of 0.00 or $p<0.05$ (Li and Yao, 2019). The VIF value shows a multicollinearity relationship between variables based on a condition number value of 16.52 or VIF > 10 (Shrestha, 2020; Wicaksono, 2022). Therefore, the results of regression diagnostics based on patterns and geographical conditions between regions indicated spatial heterogeneity (Kala et al., 2017; Leung et al., 2000). Diagnostic information was compared between the global regression and GWR models through the classic values of AIC, BIC/MDL, CV, R square, and Adj. R square to determine the best model (Fotheringham et al., 2002). Furthermore, a goodness of fit analysis was performed to ensure differences between the two models by comparing F-count and F-table values.

Table 4. Selection of the Best Model

	Model	Classic AIC	BIC/MDL	CV	R Square	Adj. R Square
Diagnostic Information	Global Regression	773.39	784.08	935605043.26	0.79	0.75
	GWR	739.44	772.57	746956568.97	0.96	0.89
	Model	**SS**	**DF**	**MS**	**F**	**F-Table**
Goodness of Fit	Global Residuals	9979167705.42	28.00	-	-	-
	GWR Improvement	8431987404.91	17.48	482200317.97	-	-
	GWR Residuals	1547180300.50	10.51	147161051.98	3.27	2.56

Source: Research finding, using GWR.

Table 6. GWR Model Parameter Estimation

Variable	Min	Lower Quartile	Mean	Upper Quartile	Max	STD
Intercept	10866.92	11684.61	18793.08	22603.45	40873.17	7952.65
GRDP	-1151.93	-82.00	5494.72	736.05	37905.16	11587.37
Unemployment	-1961.29	-1215.32	9037.13	2291.14	54828.54	19089.45
Office Network	-154764.73	-94562.20	-46565.43	-5828.49	2649.47	54495.39
COVID-19	1452.26	6534.38	27787.79	49635.45	73805.08	25230.94
Consumptive Financing	13190.57	20595.31	47826.16	89850.57	97273.70	31322.51

Source: Research finding, using GWR.

Table 7. Comparison of GWR and Global Regression Models

Variable	GWR			Global Regression		
	F	DIFF of Criterion	F-Table	T	Estimate	T-Table
Intercept	1.04	-24644003.52	2.56	5.63	18421.69	2.04
GRDP	5.58*	-531484095.9	2.56	0.34	1149.37	2.04
Unemployment	9.47*	-993956240.1	2.56	1.06	4010.01	2.04
Office Network	24.58*	-3125986135	2.56	-3.04*	-40997.24	2.04
COVID-19	24.36*	-2855401199	2.56	5.60*	32013.16	2.04
Consumptive Financing	113.98*	-6970831343	2.56	4.32*	47312.55	2.04

Source: Research finding, using GWR.

Note: * significant at 0.05.

The diagnostic information results showed that the GWR model has a smaller error than the global regression model based on the Classic AIC value of 739.44, BIC/MDL of 772.57, and CV of 746956568.97. The results of R Square and Adj. R Square also showed that the GWR model has a greater value than the global regression model, which is 0.96 and 0.89. All exogenous variables in the study model affect endogenous variables by 89.13%. It means the analysis of diagnostic information showed that the GWR model explains the diversity of patterns better than the global regression model (Chun et al., 2017; N. Liu and Strobl, 2022; Permai et al., 2021). This is because the GWR model optimizes regression analysis by considering geographical aspects in each observation area (Bourdin, 2019; Permai et al., 2019). Additionally, the goodness of fit results showed significant differences between the GWR model and the global regression model based on comparing F-count and F-table values (Fotheringham et al., 2002; Nur Edayu and Syerrina, 2018) or 3.27 > 2.56 on GWR Residuals. The GWR model is appropriate for modeling research (Yu, 2007). A GWR bandwidth section analysis was also conducted using the CV method based on adaptive gaussian parameters. It aimed to determine the Optimum Bandwidth and how the optimal radius of an area is influenced by neighbors (Weber, 2018), as follows.

Table 5. GWR Bandwidth Selection

Initial values	Bandwidth	Criterion	DIFF	CV Minimum	Bandwidth Optimum
iter 1	15.16	990415004.18	7.195	746956568.97	6.000
iter 2	10.71	932292810.20	4.447	746956568.97	6.000
iter 3	7.96	786472738.93	2.748	746956568.97	6.000
iter 4	6.26	746956568.97	1.699	746956568.97	6.000
iter 5	6.26	746956568.97	1.050	746956568.97	6.000

Source: Research finding, using GWR.

The results of the GWR bandwidth selection through the golden section search were tested up to iter 5 with an optimum value of 6,000 in the search range of 0 to 34 neighbors. The test was conducted up to 5 times to show that each region could influence six neighboring areas (Fotheringham et al., 2017; Ko et al., 2020). A smaller bandwidth means the observation area reachable by the model is also small, and the result is under smoothing (Nakaya et al., 2016; Weber, 2018). In contrast, a value that is excessively large would cause a greater bias. The range of the observation radius in neighboring areas would also be greater, meaning the

model is over smoothing and creates a trait similar to global regression (Charlton and Fotheringham, 2009; Fotheringham et al., 2017). Therefore, it is necessary to search for the optimum bandwidth for the GWR analysis to be sensitive to the weighting value of the observation site. The next stage was estimating the parameters of the GWR model to get a comprehensive analysis of each data used.

The parameter estimation results on the GWR model showed that the GRDP parameter has an estimator parameter value ranging between -1151.93 to 37905.16. GRDP could affect NPF in each province with a range of values between -1151.93 to 37905.16. Unemployment showed the estimated value of parameters influencing NPF in the range of -1961.29 to 54828.54. Moreover, the office network is suspected of contributing between -154764.73 to 2649.47 NPF. COVID-19 has a potential effect in the range of 1452.26 to 73805.08 NPF, while consumptive financing has the potential to contribute to NPF with a range of 13190.57 to 97273.70. It is important to note that the parameter estimates in the GWR model are local and vary, meaning the estimated values at each location could be different. This depends on the analysis of local coefficients through weighting in each observation area (Taus et al., 2013). Furthermore, the results of the GWR analysis estimates with global regression were compared to determine the spatial role of each variable and ensure that the results were robust.

The GWR analysis was based on F-count values > F-table (Ardianti et al., 2021; Hu et al., 2018). The spatial role of each variable was determined through positive and negative values in the Difference (DIFF) of the Criterion (Bourdin, 2019; Zhu et al., 2020). The positive and negative values indicate that the model used has no and has spatial variability, respectively. The spatial variability implies the potential to have variations in geographical local coefficient values (Fotheringham et al., 2002; Nakaya et al., 2016; Weber, 2018). The analysis showed that all exogenous variables significantly influenced NPF. GRDP, unemployment, office network, COVID-19, and consumptive financing had spatial relationships with NPF with significance values of 5.58, 9.47, 24.58, 24.36, and 113.98, respectively, all exceeding 2.56. The variables had DIFF of Criterion of -531484095.9, -993956240.1, -3125986135, -2855401199, and -6970831343, respectively. The results indicated that the variables have a significant relationship of variability and spatial heterogeneity to NPF in the general observation site. Moreover, the global regression results showed significance in variable office networks, COVID-19, and consumptive financing, with a comparison of T-count and T-table values (Bari, 2022; Wiranto et al., 2020; Yu, 2007). Spatial potential

in GRDP and unemployment variables were found through global regression. This is because the test results would be assumed to be the same and apply to each observation region (Legg, 2010; Weber, 2018). GWR analysis presented comprehensive measurements by considering geographical conditions and phenomena in each region to display different observation results (Taus et al., 2013; Yu, 2007).

The economic VUCA has negatively affected the performance of companies in each region (Baker et al., 2016), because the spread of COVID-19 has had a worse impact than in previous crises (Worley and Jules, 2020). Islamic banks could restrict financing to anticipate the risk of economic uncertainty to intermediary performance (Bilgin et al., 2021). Banks have conducted strict supervision and assistance but they cannot control the disruption of supply and demand for goods and services (Amiti et al., 2017; McKibbin and Fernando, 2020a), meaning the risk of debtor depletion rates would increase (Nugroho et al., 2020). Each region has a different ability to respond to risks. However, economic growth is essential for banks to map the financing risks. When a company experiences a decline in economic growth, it impacts the stability of the banks' financial performance debtors with increase the NPF value in Islamic banks (Chalid and Bella, 2021; Kadir et al., 2021; Kuzucu and Kuzucu, 2019). In line with Fakhrunnas et al. (2022), Damanhur et al. (2018), and Suprayitno and Hardiani (2021) that economic growth in an area contributes greatly to predicting potential defaults experienced by banks. If the economy grows well, there is a small probability of default conditions. In contrast, when economic growth decreases, it will encourage an increase in NPF for Islamic Banks, so Islamic Banks need to carry out a risk mitigation process in each of their target areas (Santoso et al., 2019).

The economic shocks from uncertain conditions have resulted in recessions in most countries, decreasing economic activity and demand for labor (OECD, 2021; Raimo et al., 2021). This condition worsens with many companies experiencing bankruptcy, promoting massive terminations (Blustein et al., 2020; Boratyńska, 2021; Wang et al., 2020). Furthermore, increased unemployment would impact the financial ability of households to pay the loan (Cooper et al., 2021). So, Islamic bank raising concerns on loan repayment during the pandemic (OECD, 2021; The World Bank, 2020). The potential financing return rate would largely depend on the number of unemployed in each region because the conditions of one region to another cannot be confused. Following Isaev and Masih (2017),

the unemployment rate strongly influences the increase in NPF in Islamic banks because the greater the number of unemployed, the potential for problematic financing will increase. The amount of unemployment reflects the economy in an area, meaning that this condition illustrates the inability of a region to carry out financing due to the large number of debtors who have the potential to lose their jobs and income (Louzis et al., 2012). In addition, Degl'Innocenti et al. (2017) and Avetisyan (2021) showed that the spread of bank office could serve to maintain the stability of NPF values because a debtor's residence or business close to the branch office makes supervision and assistance in financing to run more efficiently (Ansong et al., 2015; Sholihin et al., 2018). Additionally, distance determines the amount of financing and eligibility for a debtor to receive funding (Liberti and Petersen, 2019; A. Mufraini et al., 2020; Richards et al., 2008)

The spread of COVID-19 affects the risk of Islamic bank financing because it is handled differently by each province according to the increases in cases (Beirne et al., 2021; Erfani and Vasigh, 2018; McKibbin and Fernando, 2020b; Nugroho et al., 2020). When COVID-19 sufferers increase, so the government tightens activities. However, decreasing the number of affected people would promote easing the restrictions, allowing economic and financial activities to run normally (Wicaksono, 2022). It means that increasing social restrictions will encourage the potential increase in NPF through a decrease in income and the rate of return on debtor financing (Aldasoro et al., 2020; Flögel and Gärtner, 2020; Islamic Development Bank, 2020). Moreover, Žunić et al. (2021) explained that COVID-19 has influenced NPF. However, it was covered by the restructuring of financing by the government, so defaults were not revealed on the bank's financial statements. While Kryzanowski et al. (2023) revealed that the influence of COVID-19 on NPF arose because it was a new phenomenon for human life that had never been done before. Hence, it took time to create the best scenario so that its problems would not strongly affect the banking industry.

Debt arising from Consumptive Financing also increases NPF because financing is based on non-productive consumptive actions. When VUCA-world conditions cause changes in household income, NPF increases (Arsyianti and Kassim, 2021; Jensen and Johannesen, 2017; Teppa, 2014). Although consumptive financing is more profitable than capital financing for Islamic banks, more risks emerge during pandemic conditions (Muhammad et al., 2020). Ilmi (2018) and Priyadi et al. (2021) said that financing plays an important role in increasing NPF through delays in profit sharing by borrowers and customer failure to make timely

collections. Meanwhile, Trinugroho et al. (2021) conveyed that there is a high credit risk potential due to the moral aspect of hazard in financing contracts, so there is a need for better risk mitigation in Islamic banks. This study conducted a geographical analysis of local coefficients to show diversity in each province in responding to the risk factors of Islamic bank financing.

Table 8. Geographical Local Coefficients

No	Province	Significant Variable
1	DKI Jakarta	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
2	West Java	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
3	Central Java	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
4	DI Yogyakarta	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
5	East Java	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
6	Bali	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
7	West Nusa Tenggara	GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing
8	Maluku	Office Network, COVID-19
9	Papua	Office Network, COVID-19
10	Lampung	COVID-19, Consumptive Financing
11	DI Aceh	Office Network, COVID-19, Consumptive Financing
12	North Sumatra	Office Network, COVID-19, Consumptive Financing
13	Bengkulu	Office Network, Consumptive Financing

Source: Research finding, using GWR.

The geographical local coefficients analysis results showed that only 13 of the 34 provinces have local spatial dynamics significantly influencing NPF. These include DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, Bali, and West Nusa Tenggara. The variables affecting NPF are GRDP, Unemployment, Office Network, COVID-19, and Consumptive Financing. The influential variables in Maluku and Papua are Office Network and COVID-19, while those in Lampung are COVID-19 and Consumptive Financing. Office networks, COVID-19, and Consumptive Financing affect NPF in DI Aceh and North Sumatra

provinces. Meanwhile, Office Networks and Consumptive Financing influence NPF in Bengkulu. This study also showed that each region has different characteristics (Hill et al., 2008; Tabuchi and Thisse, 2011). There is a need for a special approach to mitigating risks in financing Islamic banks (A. Mufraini et al., 2020; Wicaksono, 2022). Geographical conditions cannot be generalized because banks deal with financing risks differently in each province depending on the economic, social, political, and infrastructure conditions (Sellar et al., 2019). Moreover, Principi (2022) shows that the risk mitigation process cannot run optimally if the bank only sees phenomena that occur in one region without considering other regions because the orientation of handling financing risks involving phenomena and conditions in the entire office network can reduce the risk of loss in Islamic bank financing (Le et al., 2020). A geographical coefficients map analysis was also conducted to determine the distribution of R Square significance values in the Model.

Figure 1. Geographical Coefficients Map
Source: Research finding, using GeoDa.

The results of the geographical coefficients map in each province were divided based on the value of R Square into five categories, including < 0.93, 0.93 – 0.94, 0.94 – 0.97, 0.97 – 0.98 and > 0.98. The category of < 0.93 has 21 provinces, including Bangka Belitung, Gorontalo, Riau, Riau Islands, South Sulawesi, South

Sumatra, West Kalimantan, Jambi, Banten, South Kalimantan, North Sulawesi, North Kalimantan, West Sulawesi, North Maluku, Central Kalimantan, East Nusa Tenggara, West Papua, Southeast Sulawesi, West Sumatra, East Kalimantan, and Central Sulawesi. The 0.93 - 0.94 category has Bengkulu, 0.94 - 0.97 has DI Aceh and North Sumatra, 0.97 - 0.98 has Lampung, Papua, and Maluku provinces, while > 0.98 has seven provinces with the highest R square value. These are DKI Jakarta, Central Java, West Nusa Tenggara, East Java, DI Yogyakarta, West Java, and Bali. Therefore, the model developed in this study contributes to NPF risk mitigation in the seven provinces included as centers of Islamic finance growth in Indonesia.

5. Conclusion

This study aimed to measure the risk factors of Islamic bank financing in each province through the variables GRDP, unemployment, office network, COVID-19, and consumptive financing. It developed a regression analysis with a geographical approach based on regional weighting at latitude and longitude coordinates. Each observation on the sample allowed to have different weights and coefficient values. Additionally, this study sought to conduct spatial mapping in each province to provide comprehensive input to policymakers to implement risk mitigation in Islamic banking after the pandemic.

The study results showed differences between the GWR model and global regression. The GWR model has proven more precise in modelling factors influencing Islamic bank financing risks through comparison at the stage. Then, all exogenous variables have the potential to have an impact on NPF in each region. In addition, the GWR model can show an undisclosed relationship in the global regression approach. In contrast, the global model only shows the relationship between Office Network, COVID-19, and Consumptive Financing to NPF. Meanwhile, the GWR model reveals a relationship between all exogenous variables to NPF because the GWR model is a development of the global regression model by utilizing geographical and spatial approaches. In addition, this study reveals variations in models on financing risks in Islamic banks in each province based on geographical local coefficients analysis. The results of the analysis show that there are only 13 provinces that have model variations, including the provinces of DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, Bali, and West Nusa Tenggara with models that affect NPF in the form of GRDP, Unemployment, Office Network, COVID-19, Consumptive Financing.

Then, Maluku and Papua province with Office Network and COVID-19, Lampung province with COVID-19 and Consumptive Financing, DI Aceh and North Sumatra provinces with Office Network, COVID-19 and Consumptive Financing, and Bengkulu province with Office Network and Consumptive Financing. In addition, the Geographical Coefficients Map shows that seven provinces have a significance level of > 0.98 in the model formed in each region, the majority of which are concentrated on the island of Java, namely DKI Jakarta, Central Java, West Nusa Tenggara, East Java, DI Yogyakarta, West Java, and Bali.

This study contributes to developing Islamic financial literature, especially in mitigating the financing risks of Islamic banks in an island country. Most studies use a global approach involving various methods and variables, so there still needs to be more literature. The global approach is often used as the basis for decision-making in the risk mitigation process. However, there are different dynamics between regions and regions, so decision-making often needs to be improved. This research has implications for mitigating the financing risks of Islamic banks in each province by maintaining liquidity levels. In managing risks, this research advises Islamic banks to tighten the verification of prospective debtors through the selection of proposals and a comprehensive assessment of collateral assets. Then, banks need to restructure financing considering each trustee's economic condition. In addition, there is a need to supervise portfolio performance by monitoring projects or asset activities and diversifying creditor exposures. Islamic banks must build digital infrastructure through GIS in each regional office by considering the dynamics in each province, making it easier for banks to predict the risks that can occur. In addition, the Central Bank and the Financial Services Authority must standardize Islamic banks' rules to create legal certainty in the new activity. Then, the government needs to ensure that every employee of an Islamic bank has a competency certification in financing management so that the supervisory function can run optimally. In addition, it is necessary to optimize the role of representatives of the Financial Services Authority and Central Bank offices in the region to conduct direct supervision in regulating the proposals of prospective debtors and recipients of Islamic bank financing restructuring in each province. However, each bank needs to disclose the value of financing restructuring in the financial statements so that it does not obscure the potential for an increase in NPF that may occur in the future. The Financial Services Authority is also expected to impose sanctions on Islamic banks that violate regulations related to the level of bank health. The study was limited to assessing financing risks in 34 provinces through

economic growth indicators, intermediation functions, and COVID-19 as exogenous variables. Therefore, further research is expected to involve more exogenous regions and variables to measure the risk factors of financing in Islamic banks in the future.

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