



Economic Resistance and Recovery of Indonesian Regency/City During the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic severely disrupted Indonesia's regional economies, exposing disparities in their ability to withstand and recover from shocks. This study explores the economic resilience of 514 regencies and cities across Indonesia during 2020–2022 by measuring two dimensions of resilience—resistance (ability to withstand contraction) and recovery (ability to rebound afterward). Using national socioeconomic and labor data, the analysis identifies key factors influencing regional resilience. The findings reveal that regions demonstrating stronger resistance during the crisis also tended to recover more rapidly. Income inequality and population size were found to weaken both resistance and recovery, while a higher share of workers using information and communication technology (ICT) enhanced post-pandemic recovery. These results highlight that improving digital inclusion and reducing income inequality are crucial policy priorities for strengthening regional resilience to future economic shocks. Strengthened coordination between central and local governments is essential to build a more adaptive and equitable economic structure nationwide.

Keywords: COVID-19, Recession, Resilience, Herfindahl Index, ICT, Income Inequality

JEL Classifications: C31, R11, R12

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1. Introduction

Economic shocks are something that will undoubtedly happen to a region and will continue to happen occasionally in different ways. Numerous shocks have been shown to have occurred throughout human civilization; these shocks are caused by natural or man-made variables, including pandemics, recessions, and natural disasters (Briguglio et al., 2009). A region gets struck by shock, particularly when it comes to the economic aspect. For example, the 2008 global financial crisis caused a shock that affected nations all over the world (Martin, 2012; Simmie & Martin, 2010). It's interesting to note how different regions differ in their susceptibility to economic shocks and capacity to adjust to major disruptions in the economic environment because the effects of the post-2008 economic crisis have been both widely distributed and contagious but also highly uneven geographically (Sensier et al., 2016).

Good shock resistance is defined as areas that can lessen the adverse effects of shocks (Martin & Sunley, 2015). Areas are said to have strong recovery if they can adapt to the conditions of the area prior to the shock and recover well once it occurs. Being well-prepared will lessen the negative effects of a shock. Strategies for dealing with shocks must consider the features of previous shocks in order to learn from them and develop policies for dealing with shocks that happen in a region (Di Caro, 2015). Particularly in industrialized nations, there is now more research examining the regional effects of shocks (Bailey et al., 2020; Bourdin et al., 2021). The COVID-19 epidemic is the shock that recently swept through every nation on the planet.

China was the initial location of the COVID-19 pandemic outbreak in 2019. The World Health Organization (WHO) declared the ongoing epidemic to be a worldwide pandemic on March 11, 2020 (Dong et al., 2020). From a health standpoint, COVID-19 is a shock that targets local economic situations (Chen et al., 2021; Dong et al., 2020). Although the COVID-19 pandemic initially mainly created health problems in the area, its effects also caused economic disruption.

According to Figure 1(a), the global economy shrank by -3.11 percent in 2020, as did the economies of the OECD, lower middle-income, and upper middle-income nations. The COVID-19 pandemic may have contributed to the contracting circumstances that were experienced. The world economy gradually started to rebound in 2021 as a result of initiatives put in place by nations all over the world to combat the 2020 economic crisis; therefore, this contractionary state did not persist long. Indonesia too experienced this global economic situation.

The GDP of Indonesia has grown between 2010 and 2019, as seen in Figure 1(b). The GDP of Indonesia was 6,864.13 trillion rupiah in 2010, and it grew to 10,949.16 trillion rupiah in 2019. Indonesia's GDP dropped to 10,723 trillion rupiah in 2020. It is believed that this is the result of the COVID-19 epidemic that started in Indonesia in 2020. When COVID-19 instances started to show up in Indonesia in 2020, the country's economy responded by contracting (BPS, 2020). Indonesia was spared the effects of the slump for a considerable amount of time, as the country's GDP grew to 11,710.4 trillion rupiah in 2021. Regions around Indonesia were also affected by the COVID-19 pandemic's effects on the local economy. Indonesia's economic growth shrank by 2.07 percent in 2020 (see Figure 2(a)). The decrease in the economic growth of the vast majority of Indonesia's provinces can be used to characterize the country's economic downturn. With economic growth contraction figures of 9.34%, 3.8%, and 3.39%, respectively, Bali, Riau Islands, and Banten were the three provinces that saw the most decline in economic growth in 2020. However, three provinces—Central Sulawesi, North

Maluku, and Papua—saw the expansion of economic growth, with increases in economic growth values of 4.86 percent, 5.39 percent, and 2.39 percent, respectively. The contraction in economic growth that occurred nationally was allegedly due to the shock caused by the COVID-19 pandemic, which began to hit Indonesia in 2020. The Indonesian government put in place the Large-Scale Social Restrictions (Pembatasan Sosial Berskala Besar/PSBB) policy in 2020 in order to address this issue (Yamali & Putri, 2020).

Figure 1: World Economic Growth Rate 2010-2021(a) and Indonesia's GDP 2010-2022(b)

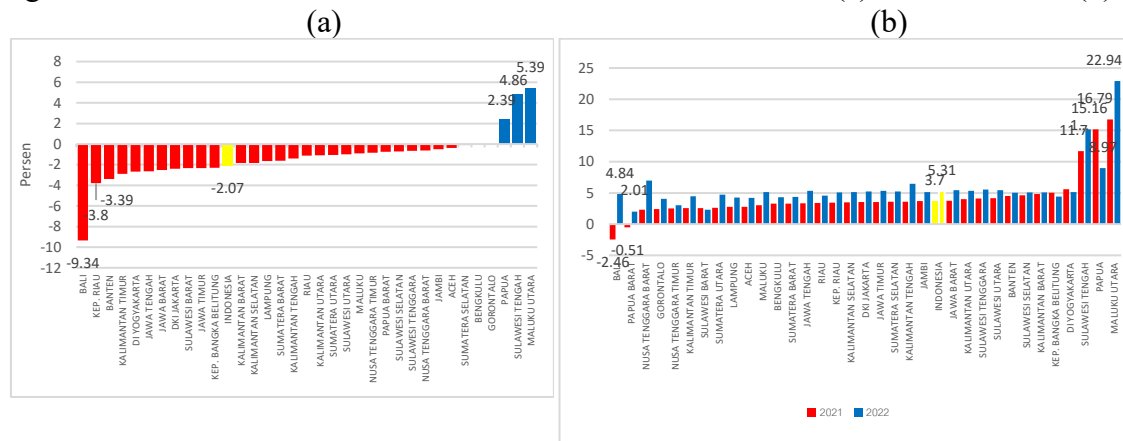


Source: World Bank and BPS-Statistics Indonesia.

All regular operations were halted due to the PSBB's implementation, which was outlined in PP no. 21 of 2020 (Olivia et al., 2020). The office and industrial sectors were compelled to temporarily halt all operations. In addition, the same thing is happening in the fields of education, public services, places of worship, retail establishments, dining establishments, and tourism destinations. In response to the COVID-19 epidemic, the Indonesian government has enforced Community Activity Restrictions (Pemberlakuan Pembatasan Kegiatan Masyarakat/PPKM) since the start of 2021. In many locations where COVID-19 has expanded, particularly on the islands of Java and Bali, PPKM has been put into practice (Miharja et al., 2021). The goal of multi-level PPKM implementation is to treat areas in accordance with the pandemic condition at hand. Regencies and cities, which are smaller than provinces, are the focus of multilevel PPKM. Regions of Indonesia have gradually started to react to this policy, as seen in Figure 2(b), which shows improvements in macro conditions in the form of faster economic growth.

The expansion of Indonesia's economy in 2021 and 2022 was 3.7 percent and 5.31 percent, respectively, as Figure 3(b) illustrates. The expansion of Indonesia's economy in 2021 and 2022 can be explained by the economic growth of its provinces, most of which saw economic growth expansion. While economic growth is expanding in all Indonesian regions, Central Sulawesi, Papua, and North Maluku saw the biggest increases in 2021 and 2022. Though two provinces—Bali at -2.46 percent and West Papua at -0.56 percent—saw a slowdown in economic growth in 2021. The majority of Indonesia's regions in 2021 and 2022 went through a recovery phase following the 2020 COVID-19 shock, according to a perspective on regional resilience (Martin et al., 2016).

Figure 2: Provincial Economic Growth Rate in Indonesia in 2020(a), 2021 and 2022(b)



Source: BPS-Statistics Indonesia.

Given the effects of the COVID-19 shock on the Indonesian economy in 2020 and the differences in the effects of COVID-19 on the regional economy, this study aims to examine how resilient Indonesian regencies and cities are to the COVID-19 pandemic. Following the 2008 monetary crisis, economic scholars worldwide started talking about regional resilience (Davoudi et al., 2012; Eraydin, 2016; Martin, 2012). Meanwhile, economic scholars worldwide are beginning to talk about the issue of regional resilience during the COVID-19 pandemic (Gong et al., 2020).

There is conflicting data from a number of empirical research studies regarding how the COVID-19 epidemic affected regional resilience. Gong et al. (2020) discovered that regional resilience was impacted by COVID-19. As a result, studies are required to determine how resilient the cities and regencies of Indonesia were to the COVID-19 pandemic. According to the author's knowledge, no research has ever been done on Indonesia's regional resilience to the COVID-19 pandemic shock. In light of this, the research's objectives are to: (1) use a workforce share approach to identify and characterize regency/city specialization; (2) characterize regency/city resilience; and (3) examine the variables that affect Indonesian regencies' and cities' ability to withstand the shock of the COVID-19 infection. With regard to regency/city resilience, it is intended that the findings of this study serve as a foundation for policy decisions in order to prepare for potential future shocks.

2. Literature Review

The notion of resilience in the face of shock used in this study is based on Martin & Sunley's (2015) assumption that the economy functions as a system. The first step in dealing with a shock is for the economic system to be at risk or vulnerable to one. Then there was a jolt to the economy. Changes required to preserve system conditions can be accommodated by the economic system. The economic system then bounces back from the shock. According to Martin & Gardiner (2019), there are two types of regional resilience during a shock: post-shock regional recovery with a recoverability index that takes place during a period of national economic expansion and regional resistance with a resistance index that takes place during a period of national economic contraction. Two resilience metrics are calculated as follows:

Resistance index

$$RESIS_c = \frac{\Delta Y_c^{Contraction} - \Delta E(\Delta Y_c^{Contraction})}{|\Delta E(Y_c^{Contraction})|} \quad (1)$$

Recoverability index

$$RECOV_c = \frac{\Delta Y_c^{expansion} - \Delta E(\Delta Y_c^{expansion})}{\Delta E(Y_c^{expansion})} \quad (2)$$

Contraction is defined as the time when the shock occurs, while expansion is defined as the recovery time after the shock. $\Delta Y_c^{Contraction}$ or $\Delta Y_c^{Expansion}$ is the change in GRDP of the c-th regency/city during the contraction or expansion period from year t to year t-k. $\Delta E(Y_c)$ is the expected change in GRDP of the c-th regency/city during the contraction or expansion period from year t to year t-k:

$$\Delta E(Y_c^t) = \left(\frac{Y_{Idn}^t - Y_{Idn}^{t-k}}{Y_{Idn}^{t-k}} \right) Y_c^{t-k} \quad (3)$$

where $\Delta E(Y_c^t)$ is the expected change in GRDP of the c-th regency/city in year t with year t-k; Y_{Idn}^t is a country's GDP in year t; Y_{Idn}^{t-k} is a country's GDP in year t-k; Y_c^{t-k} is the GRDP of the c-th regency/city in the year t-k. A negative value of $RESIS_c$ indicates that the c regency/city has poor resistance to shocks, whereas a positive value indicates that the regency/city has good resistance to shocks. The same concept is also applied to $RECOV_c$.

Regional resilience is thought to be impacted by regional specialization. More specialized regions are more resilient to shocks (Annoni et al., 2019). Cuadrado-Roura & Maroto (2016) discovered that during the 2008 recession, a number of Spanish regions displayed resilience behavior. Formerly specialized areas with more productive industries, like manufacturing, energy, and services, recovered more quickly and robustly. Using the 17 sectors specified in the Standard Classification of Indonesian Business Fields (SCIBF), the Herfindahl Index (Geelhoed et al., 2021) was used as the measure of regency/city specialization in this study.

$$Herfindahl_c = \sum_{i=1}^n \left(\frac{E_{c,i}}{E_c} \right)^2 \quad (4)$$

where $E_{c,i}$ is the number of workers in the i-th sector of the c-th regency/city; E_c is the number of workers in the c-th regency/city. $Herfindahl_c \in (0,1)$, a value of 1 indicates that the distribution of labor in the c-th regency/city is concentrated in 1 sector and a value close to 0 indicates that the distribution of labor in the c-th regency/city is spread across 17 sectors according to with SCIBF.

Regional development is proxied using GRDP (Martin & Gardiner, 2019). GRDP is the sum of the values of all products and services produced by a country (Kartiasih, 2019a, 2019b; Kartiasih & Setiawan, 2020). A higher GDP indicates a stronger economic situation and hence a more optimistic picture of the economy (Adwendi & Kartiasih, 2016; Hawari & Kartiasih, 2017; Ningsih & Kartiasih, 2019). According to a number of experts, resilience and urban production are negatively correlated (Annoni et al., 2019; Crescenzi et al., 2016). There is evidence, according to Martin & Gardiner (2019), that

economic structure influences how resilient different UK cities are. Analyzing regional resilience requires taking into account not just the regency's or city's numerical size but also the population's quality. A region's population quality is thought to be reflected in the human development index (Kusumasari & Kartiasih, 2017). Masten & Obradovic (2008) found that the quality of human development is necessary to explain resilience.

Population growth is a significant factor in disaster or shock response, in addition to human development. More attention is required for the population because a shock that affects the population will upset the region, particularly from an economic standpoint. Various economic agglomerations are said to assist in increasing the productivity of large cities (Martin & Gardiner, 2019). Using the population as a stand-in for the agglomeration effect, big cities ought to be more resilient to shocks to the economy. Because a population of better quality will undoubtedly increase the region's resilience to shocks, it is important to make sure that the population possesses fundamental knowledge and abilities, such as the use of ICT (Kartiasih et al., 2023; 2023a; 2023b).

3. Methodology

This research covers 514 regencies/cities in Indonesia with a research period of 2020-2022. The dependent variable in this study is regional resilience. The resistance index, which measures regional resistance, and the recoverability index, which measures regional recovery following a shock, are the two methods used to quantify regional resilience.

The independent variables in this study are income inequality, which is proxied by the Gini ratio; share of labor in the manufacturing industry sector; regional specialization which is proxied by the Herfindahl index; labor productivity; population; quality of human development, represented by the human development index (HDI); and share of labor who uses information and communications technology (ICT) such as cell phones, computers, and the internet. This study uses secondary data from the raw National Labor Force Survey (Sakernas) data conducted by BPS-Statistics Indonesia from August 2020 to 2022. Sakernas raw data is used to measure a regional specialization called the Herfindahl index. The BPS website provides information on population, Gini ratio, share of labor in the manufacturing industry sector, labor productivity, HDI, and share of labor who uses ICT.

This study uses descriptive analysis and inferential analysis to describe the resilience of regencies/cities to the shock of the COVID-19 pandemic. Descriptive analysis was carried out to provide an overview with scatter plots and thematic maps. The study's inferential analysis, Robust MM-Estimation Regression, is used to examine two conditions: the region's recovery conditions from the COVID-19 pandemic shock that occurred during the economic expansion in 2021-2022 and the resistance conditions to the COVID-19 pandemic shock that occurred in regencies/cities in Indonesia during the economic contraction in 2020. The stages of analysis in this study are as follows:

1. Checking Spatial Relationships between Regencies/Cities

Spatial association can be identified using Global Moran's I, which helps to check spatial autocorrelation across regions. If the Moran's I value is significant, then spatial regression is needed; if it is not significant, then multiple linear regression is done without considering spatial effects between regencies/cities.

2. Estimation of parameters of multiple linear regression model

The method used to estimate the regression model parameters is the Ordinary Least Square (OLS) method. The regression parameter estimation will be Best Linear

Unbiased Estimation (BLUE) if it meets the classical assumptions of linear regression. Before the regression estimation is carried out, it is necessary to check the correlation between independent variables using the Variance Inflation Factor (VIF). If the VIF value is <10, then there is no multicollinearity between independent variables. The following is the regression model in this study.

Multiple Linear Regression Model for Resistance:

$$RES_i = \beta_0 + \beta_1 Gini_i + \beta_2 Manuf_i + \beta_3 Herfindahl_i + \beta_4 Prod_i + \beta_5 lnPop_i + \beta_6 HDI_i + \beta_7 ICT_i + \varepsilon_i \quad (5)$$

Multiple Linear Regression Model for Recoverability:

$$RECOV_i = \beta_0 + \beta_1 Gini_i + \beta_2 Manuf_i + \beta_3 Herfindahl_i + \beta_4 Prod_i + \beta_5 lnPop_i + \beta_6 HDI_i + \beta_7 ICT_i + \varepsilon_i \quad (6)$$

where RES_i is the resistance index; $RECOV_i$ is the recoverability index; $Gini_i$ is the Gini ratio; $Manuf_i$ is share of labor in the manufacturing industry sector; $Herfindahl_i$ is the Herfindahl index; $Prod_i$ is the labor productivity; $lnPop_i$ is the population in the form of a natural logarithm; HDI_i is the human development index; ICT_i is share of labor who uses ICT; β_0 is the intercept of the resilience model; $\beta_1 \dots \beta_7$ is the regression coefficient of the independent variable; ε_i is an error term; i is a subscript to indicate the regency/city, $i = 1, 2, \dots, 514$.

Before conducting the regression analysis, a check was made on the assumptions of normality and homoscedasticity of the dependent variables, namely regency/city resistance and regency/city recovery. Furthermore, outlier detection was carried out; if outliers were found, robust regression was needed.

3. Classical Assumption Testing

Testing classical assumptions on cross-section data includes normality tests and homoscedasticity tests. The following are classical assumption tests: (i) Examination of normality assumptions using the Kolmogorov-Smirnov Test. Reject H_0 if the D value > D table or p-value < 0.05. Reject H_0 indicates that with a significance level of 5%, the resulting regression equation has an error that is not normally distributed or the normality assumption is not met. (ii) Testing the assumption of homoscedasticity using the Breusch-Pagan Test. Reject H_0 if p-value < 0.05, which means the homoscedasticity assumption is not met. Next, outlier detection and influential observations are performed. The existence of influential observations in the model is a sign that robust regression is needed.

4. Outlier detection

i. Leverage Value.

Influential observations are detected if the observations have a leverage value that is greater than the cutoff leverage value.

ii. DFFITS

Outlier is considered an influential observation using DFFITS values.

$$DFFITS = t_i \sqrt{\frac{h_{ii}}{1-h_{ii}}} \quad (7)$$

where h_{ii} is the value leverage observation i .

5. Robust Regression Analysis

Estimating regression parameters using robust regression can accommodate data that has outliers. The method used in this study is MM-estimation because it has a high breakdown point and high efficiency.

6. Estimation Parameter Testing-MM

i. Simultaneous Test.

Reject decision if $F_{stat} > F_{table}$ has a significance level of 5%.

ii. Partial Test.

Partial testing can be done by using the t-test on the equation. Reject H_0 if $t_{stat} > t_{table}$ has a significance level of 5%, which means that the k-th independent variable has an effect on the dependent variable.

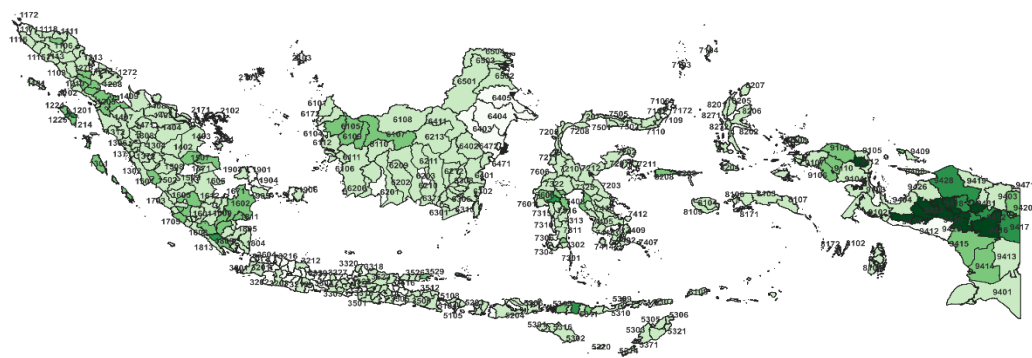
4. Findings

4.1 The Regency/City Specialization and Resilience in Indonesia

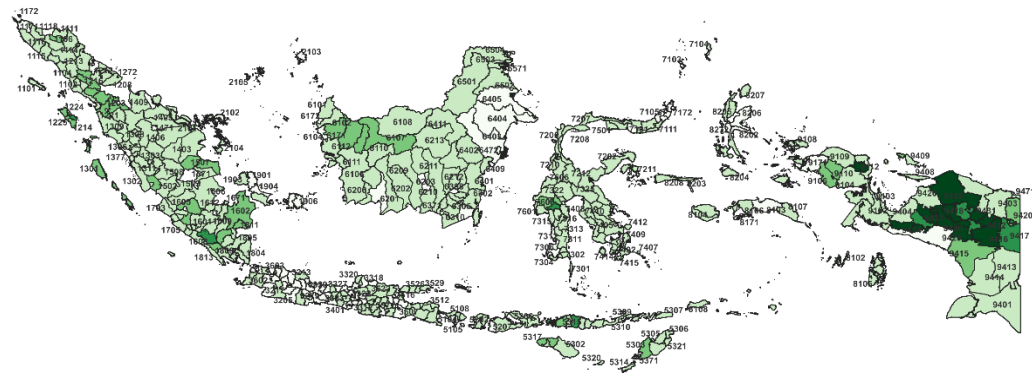
Regency/city specialization in this study uses the Herfindahl index, which calculates specialization using the number of workers in each sector in a regency/city. Figure 3 displays the specialization of regencies/cities in Indonesia using the Herfindahl index (HI). The higher the HI value, the darker the regency/city area on the thematic map, indicating that the distribution of the regency/city workforce is increasingly specialized into certain sectors. On the other hand, the lower the HI value, the brighter the regency/city area on the thematic map, indicating that the distribution of the regency/city workforce is increasingly spread across various sectors. The range of Herfindahl index values for regencies/cities in Indonesia from 2020 to 2022 ranges from 0.14 to 0.97, which indicates that the distribution of regency/city workers in Indonesia is very spread out or diverse.

The distribution of regency/city workforces in Indonesia has not experienced any significant changes during 2020-2022. The western region of Indonesia has regencies/cities whose workforce works in various sectors, especially those on the island of Java and the island of Kalimantan. Meanwhile, in regencies/cities in eastern Indonesia, the distribution of regency/city workforce is more specialized into several sectors, especially those in the Papua region. The distribution of the regency/city workforce in the Papua region tends to be specialized in certain sectors such as agriculture, education, and health services. Java Island has a regency/city workforce distribution that is more spread out across several sectors, the majority of which are in the processing industry, agriculture, construction, transportation and warehousing, wholesale and retail trade sectors, and repair and maintenance of cars and motorbikes. During 2020-2022, the region with the highest Herfindahl index value was Bontang City (East Kalimantan), and the lowest was Lanny Jaya Regency (Papua).

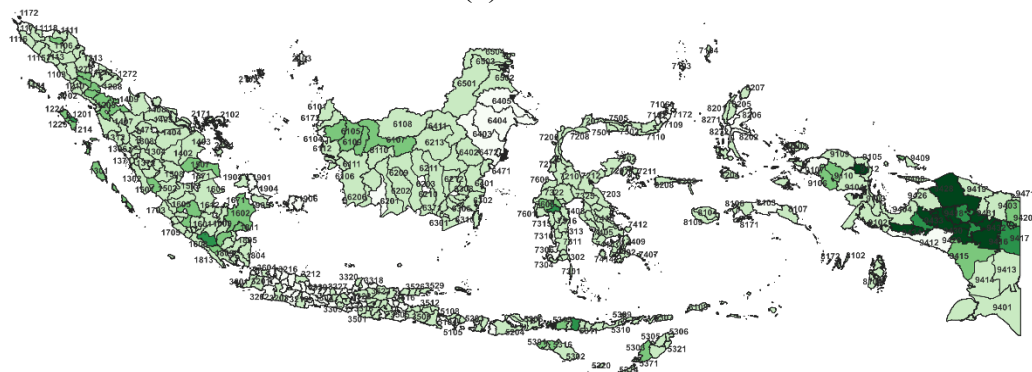
Figure 3: Herfindahl Specialization Index Regency/City in Indonesia



(a). 2020



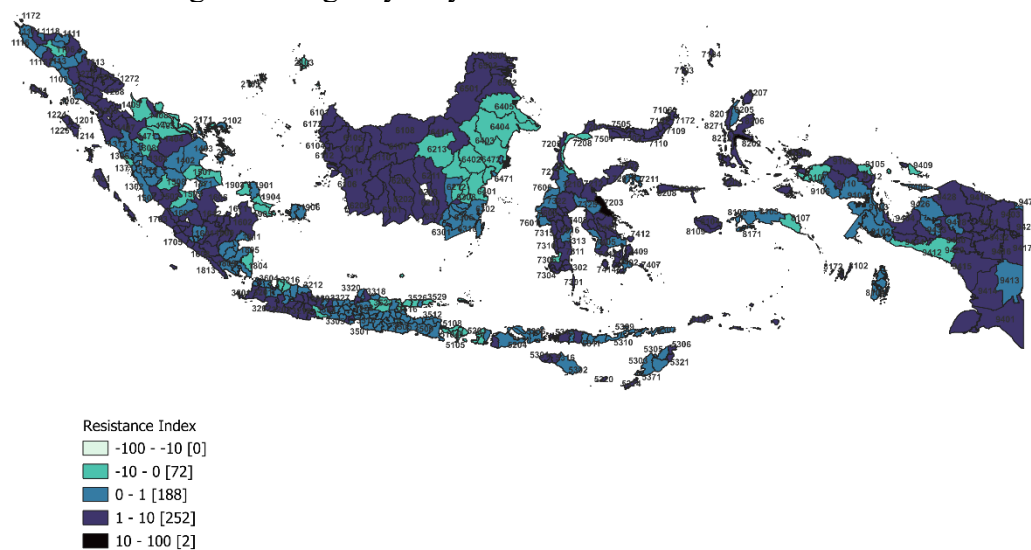
(b). 2021



(c). 2022

Source: Authors' own preparation.

Figure 4: Regency/City Resistance Index in Indonesia 2020



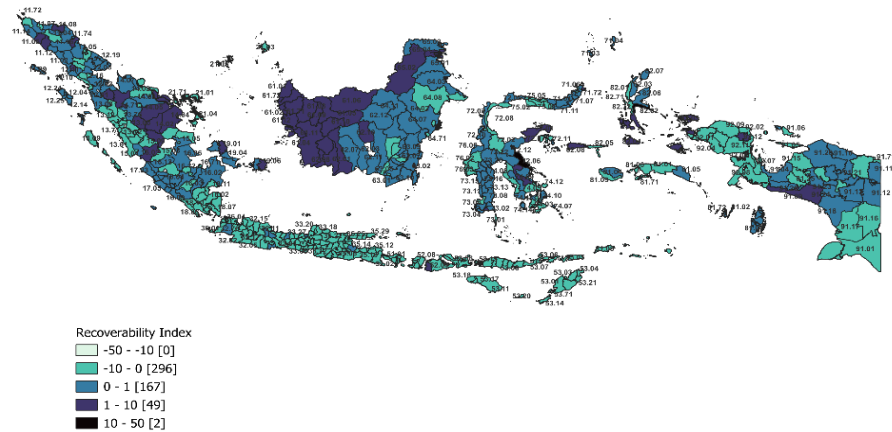
Source: Authors' own preparation.

Resilience is a measure of the ability of an economic system to withstand the impact of shocks and recover successfully from shocks that disrupt the economic system. Based on studies by Martin et al. (2016), areas that have good resistance to shock have a resistance index value greater than 0. On the other hand, a resistance index value less than 0 indicates that the region has poor resistance to shocks. Figure 4 shows that in 2020 the majority of regencies/cities had good resistance to the shock of the COVID-19 pandemic, namely, 442 regencies/cities in Indonesia. Meanwhile, the remaining 72 regencies/cities had poor resistance to shock because they had a resistance index value of less than 0.

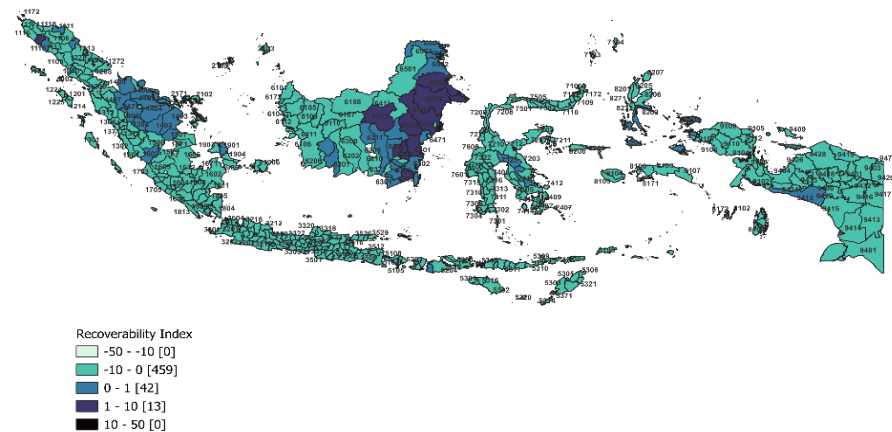
Figure 4 shows that in 2020 the majority of regencies/cities in eastern Indonesia had good ability to withstand the shock (resistance) of COVID-19, except for regencies/cities in the Bali and Nusa Tenggara regions. Regency/city areas in the Sulawesi region have the best ability to withstand the shock (resistance) of COVID-19 in the eastern region of Indonesia. Meanwhile, the majority of regencies/cities in the western region of Indonesia have the ability to withstand the shock (resistance) of COVID-19 less well than regencies/cities in the eastern region of Indonesia. The majority of regencies/cities on the island of Java are less resistant to the COVID-19 shock, while the regencies/cities on the island of Kalimantan have the best ability to withstand the COVID-19 shock (resistance) in western Indonesia.

Figure 5(a) shows that, in 2021, most Indonesian regencies and cities have the capacity to recover (recoverability) from the COVID-19 shock, which is not favorable; most of these regencies and cities are located on the islands of Java, Bali, Nusa Tenggara, Maluku, and Papua. Nearly every regency or city in Indonesia in 2022 likewise has inadequate recovery capacities following the COVID-19 shock, as seen in Figure 5(b). Nonetheless, a number of regions and cities in the provinces of Riau, East Kalimantan, and North Kalimantan have the capacity to bounce back quickly from the COVID-19 pandemic. In 2022, a small number of regencies/cities will have the ability to recover quickly from the COVID-19 pandemic, namely 55 regencies/cities in Indonesia. Meanwhile, the remaining 459 regencies/cities had poor recoverability to shock because they had a recoverability index value of less than 0. The region with the highest recoverability index value is Halmahera Tengah Regency, while the lowest is Morowali Regency.

Figure 5: Regency/City Recoverability Index in Indonesia



(a). 2021



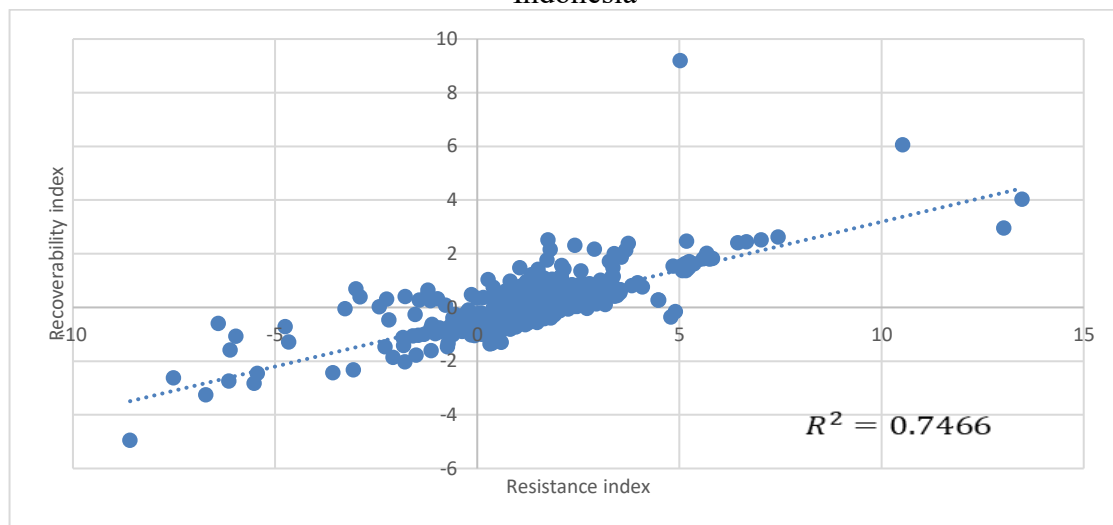
(b). 2022

Source: Authors' own preparation.

A closer look at specific regions further illustrates the contrast between areas with exceptionally strong and weak economic resilience. In terms of resistance, several regencies and cities in Kalimantan, particularly those with diversified employment structures, consistently recorded the highest resistance scores during the 2020 shock, while the lowest values were observed in parts of Java, where urban service-oriented economies were more severely disrupted. Meanwhile, the Herfindahl index values also show structural extremes: Bontang City had the highest sectoral concentration, whereas Lanny Jaya Regency had the most diversified workforce structure. For recoverability, Halmahera Tengah Regency achieved the highest recoverability index, reflecting its ability to rebound quickly, while Morowali Regency recorded the lowest recovery score. These regional contrasts reinforce the broader findings by showing how sectoral composition, specialization patterns, and regional economic structures directly shape a region's ability to withstand and recover from large-scale shocks.

Figure 6 shows the relationship between the resistance index in 2020 and the recoverability index in 2022 of regencies/cities in Indonesia. The correlation between resistance to shock and post-shock recovery of regencies/cities in Indonesia is 0.7466, which can be interpreted to mean that regencies/cities that have good resistance to the COVID-19 pandemic shock will tend to have good post-shock recovery of the COVID-19 pandemic.

Figure 6: The Relationship between the Resistance Index and the Recovery Index in Indonesia



Source: Authors' own preparation.

4.2 Resilience of Regencies/Cities in Indonesia to the Shock of the COVID-19 Pandemic

Detection of non-multicollinearity assumptions needs to be done before regression modeling is carried out. The non-multicollinearity assumption test uses the variance inflation factor (VIF) indicator with a cutting point of 10. Based on the VIF value, it shows that there is no multicollinearity between the independent variables. The next step is regression using ordinary least squares (OLS) estimation. The OLS model estimation results for 2020 to 2022 are shown in Table 1.

Table 1: OLS Estimation Results

Variables	Resistance (2020)	Recoverability (2021)	Recoverability (2022)
(1)	(2)	(3)	(4)
Intercept	-2.4265 (3.0240)	-0.2606 (1.7948)	1.4149*** (0.4724)
Gini ratio	-9.2482*** (1.7426)	-3.0179** (1.0799)	-1.2213*** (0.3330)
Manufacture	0.1692*** (0.0376)	0.0960*** (0.0205)	-0.0114** (0.0035)
Herfindahl index	11.3849*** (1.7685)	4.4505*** (1.0865)	-0.6917** (0.2281)
Labor productivity	0.0087*** (0.0014)	0.0073*** (0.0006)	0.0005*** (0.0001)
ln population	-1.4107** (0.5181)	-0.5511 (0.3239)	-0.0402 (0.0538)
HDI	0.1453** (0.0514)	0.0251 (0.0318)	-0.0165* (0.0064)
ICT	-0.0444 (0.02584)	-0.0094 (0.0129)	0.0057* (0.0023)
Observations	514	514	514
Adj R-squared	0.9592	0.9844	0.1044
F-statistic	1739	4659	9.545

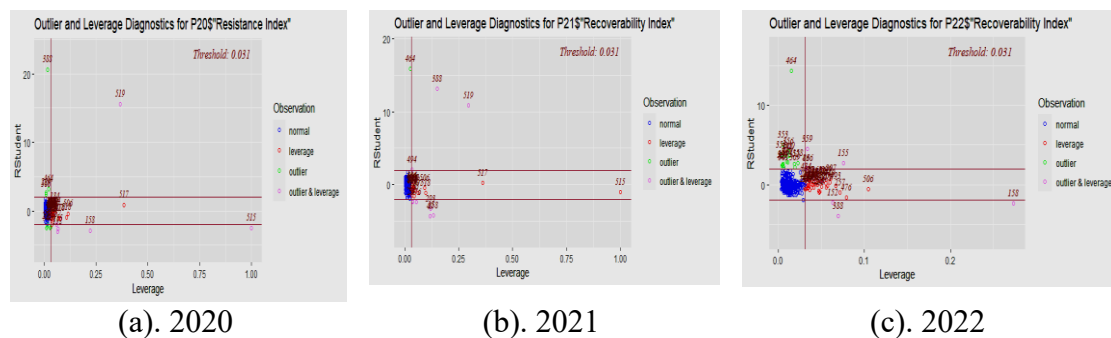
Variables	Resistance (2020)	Recoverability (2021)	Recoverability (2022)
(1)	(2)	(3)	(4)
Prob (F-statistic)	0.0000	0.0000	0.0000

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors' calculations.

The classic assumptions tested are the normality assumption and the homoscedasticity assumption. The normality assumption test used in this research is the Shapiro-Wilk test. The test statistical value is 0.4732-0.6791 with a p-value smaller than the significance level $\alpha = 5\%$, so the decision taken is to reject H_0 ; it can be concluded that the normality assumption is not met. The test for the homoscedasticity assumption used in this research is the Breusch-Pagan test. The test statistical value has a p-value of 0.00, which is smaller than the significance level $\alpha = 5$ percent, so the decision taken is to reject H_0 . Therefore, it can be concluded that the homoscedasticity assumption is not met. Normality assumptions and homoscedasticity assumptions that are not met are likely due to outliers. Outliers are defined as data that has characteristics that are very different from other observations. Outliers cause the residual distribution to be non-normal. Figure 7 presents the results of outlier detection using leverage values.

Figure 7: Outlier Detection Result

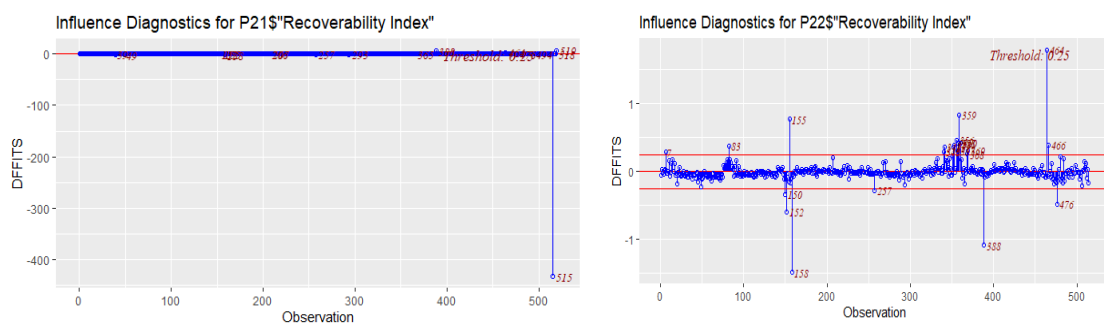


Source: Authors' calculations.

Based on Figure 7, it can be seen that there are outliers detected in the data, namely as follows: (i) Vertical outliers, observations that are included in this type of outlier, are observations that are located above or below observations that have a low leverage value and below the outlier threshold. (ii) High leverage: observations that are classified as high leverage are observations that are below the outlier threshold but have a high leverage value. (iii) High-leverage and outlier observations that are classified as high-leverage and outlier are observations that are outliers and have high-leverage values. In the 2020 regression model, the observations that fall into the high leverage and outlier category are the 517 and 519 observations. Meanwhile, in the 2021 regression model, observations that fall into the high leverage and outlier category are 388 and 519 observations, while in 2022, it is 155 observations.

The DFFITS value is a technique that can be used to identify observations that could have an impact on the regression model. In Figure 8, the DFFITS value plot is displayed. Observations 39, 49, 206, 257, 293, 365, and 388 were identified as influential observations in the 2021 regression model. Observations 7, 150, 152, 155, 257, 359, 388, 466, and 476 were identified as influential observations in the 2022 regression model; hence, the robust regression estimation method must be used to continue the study.

Figure 8: Detection of Influenced Observations in the Regression Model



(a). 2021

(b). 2022

Source: Authors' calculations.

The estimation results using MM-Robust Regression are presented in Table 2. Based on the resistance model estimation results in Table 2 column 2, it can be seen that income inequality (Gini ratio) has a negative and significant effect on regency/city resistance to the shock of the COVID-19 pandemic. This finding is consistent with Geelhoedt et al. (2021) who found worse recoverability and less resistance to economic shocks in areas with a more unequal income distribution. There is a correlation between income inequality and employment resilience. In addition, high levels of inequality are also expected to reduce the economy's ability to resist economic downturns. There are numerous explanations for this. Many people in highly unequal regions have a tendency to be heavily indebted, which impairs their ability to respond to unfavorable income shocks. Households with higher incomes are less likely to consume and have better chances to avoid paying taxes, which reduces public revenue capacity and makes it harder for governments to fund safety nets and public goods (Van Treeck, 2012).

The Herfindahl index, which measures regional specialization, significantly and favorably affects regency/city resilience to the COVID-19 pandemic shock. The impact of regional specialization on regency/city resilience to the COVID-19 pandemic shock is detrimental and substantial. The findings of Martin & Gardiner (2019) indicate a city's resilience to shocks increases with its level of specialization and are consistent with our results. The contrary of this research was observed in the study of Geelhoedt et al. (2021), which revealed that cities with a few leading sectors, when a shock occurs, become disrupted in their economic activities so that regencies/cities will have poor resistance to shocks.

Regency/city resilience to the COVID-19 pandemic shock is significantly impacted by population. In densely populated places, this epidemic spread swiftly. A regency or city's ability to withstand the COVID-19 epidemic is negatively correlated with its population density. The share of labor who uses ICT has a negative and significant effect on regency/city resistance to the shock of the COVID-19 pandemic. In 2020, when the COVID-19 pandemic began, people were unprepared, and most of their activities were carried out from home. The large number of workers who use ICT also need to adapt work patterns from the office to home, but this has not significantly increased regency/city resistance.

Share of labor in the manufacturing industry sector, labor productivity, and human development index (HDI) do not significantly influence regency/city resistance to the shock of the COVID-19 pandemic. The HDI has a negative but not significant effect on regency/city resistance to the shock of the COVID-19 pandemic. The same conclusions were reached by Martin & Gardiner (2019), who discovered a negative association and no substantial impact of human capital. This suggests that a city or regency with a high

HDI will not be as resilient to shocks. This occurs as a result of residents in high HDI areas working in industries subject to PSBB restrictions. The linear regression model obtained has an adjusted R^2 value of 0.2722. Based on the results of the simultaneous test, it can be concluded that there is sufficient evidence to state that there is at least one independent variable that is significant in regional resistance to the shock of the COVID-19 pandemic.

Table 2: Results of the MM-Robust Regression

Variables	Resistance (2020)	Recoverability (2021)	Recoverability (2022)
(1)	(2)	(3)	(4)
Intercept	3.7738*** (0.5384)	2.1012* (0.9294)	-0.3150 (0.1881)
Gini ratio	-2.3458** (0.8615)	-2.3288*** (0.5074)	-0.2752* (0.1071)
Manufacture	-0.0118 (0.0061)	-0.0141*** (0.0042)	-0.0039** (0.0013)
Herfindahl index	0.3625*** (0.3852)	-0.2725 (0.3147)	-0.1582* (0.0777)
Labor productivity	-0.0007 (0.0011)	-0.0001 (0.0001)	0.00003 (0.0000)
ln population	-0.4018*** (0.0892)	-0.2025** (0.0688)	-0.0022 (0.0176)
HDI	0.0089 (0.0083)	0.0011 (0.0102)	-0.0008 (0.0022)
ICT	-0.0146** (0.0050)	-0.0028 (0.0034)	0.0017* (0.0008)
Observations	514	514	514
Robust RSE	0.8619	0.5473	0.1612
Adj R-squared	0.2722	0.1391	0.0543
F-statistic	32.67	10.23	4.06
Prob (F-statistic)	0.0000	0.0000	0.0000

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Author's calculations.

The results of the recovery model estimation can be seen in Table 2, columns 2 and 3. The linear regression models for 2021 and 2022 obtained have adjusted R^2 values of 0.1391 and 0.0543, respectively. Based on the results of the simultaneous test, it can be concluded that there is sufficient evidence to state that there is at least one independent variable that has a significant influence on regional recovery after the shock of the COVID-19 pandemic. Overall, the adjusted R^2 values suggest that the model fits the recovery phases more accurately than the recovery phases themselves. Given that recessionary contractions have different causes and, consequently, effects, it may be predicted that there would not be a requirement for consistency between downturn (resistance) and recovery stages.

Similar to the resistance model estimation results, income inequality has a negative and significant effect on the recovery of regencies/cities from the shock of the COVID-19 pandemic. This study's findings support those of Geelhoed et al. (2021), who found that severe inequality lessens the resilience-boosting effects of increased average income. Furthermore, we discover evidence that suggests inequality contributes to a

slower rate of recovery, primarily in smaller regencies. Therefore, the study's findings indicate that income inequality is negatively correlated with both resistance and recovery. The coefficient suggests that a 1% increase in the Gini coefficient is estimated to result in 2.34% less resistance and less recoverability for Indonesian regencies/cities in 2021 and 2022, with respective values of 2.33% and 0.27%.

This negative impact of income inequality on economic resilience can be further explained through several mechanisms. First, regions with high inequality often exhibit disparities in consumption capacity, where lower-income households reduce spending during shocks, dampening aggregate demand and slowing recovery (Eraydin, 2016; Martin & Sunley, 2015). Second, unequal access to financial resources and capital limits the ability of small businesses and households to absorb shocks or invest in adaptive strategies, thereby weakening regional resistance (Martin, 2012; Martin et al., 2016). Third, social and institutional factors are affected: high inequality can reduce the effectiveness of public policies and social safety nets, as wealthier groups may influence policy in ways that do not benefit the broader population, ultimately constraining collective economic resilience (Gong et al., 2020; Geelhoedt et al., 2021; Martin & Gardiner, 2019). Understanding these mechanisms clarifies why regions with greater income disparities face both lower resistance to shocks and slower recovery, emphasizing the importance of inclusive policies to strengthen resilience at the regency/city level.

Regional recovery following the COVID-19 pandemic shock is significantly impacted negatively by the labor share in the manufacturing industry sector. A city is less resilient to the COVID-19 pandemic in terms of both resistance and recovery if a larger portion of its economy is made up of manufacturing activity. The industrial sector is the sector affected by the pandemic. Industrial sector activities have been disrupted and cannot operate due to the implementation of PPKM. Regional specialization has a negative and significant impact on regional recovery after the shock of the COVID-19 pandemic. The findings of this research are in line with Martin & Gardiner's (2019) study, which found that the more specialized a city is, the worse the post-shock recovery will be. Different results were found in the study by Geelhoedt et al. (2021), which found that the more specialized an area, the more it will increase post-shock recovery.

Population has a negative and significant effect on the recovery of regencies/cities from the shock of the COVID-19 pandemic. The larger the population, the worse the regency/city will have a post-shock recovery rate, because more residents will be affected by COVID-19. The share of labor who uses ICT has a positive and significant effect on regency/city recovery from the shock of the COVID-19 pandemic. With the adoption of PPKM, workplaces have shifted from working from the office (WFO) to working from home (WFH) through the use of information and communication technology (ICT). ICT use at work does not result in lower productivity and labor output. A greater number of ICT-equipped personnel will hasten the region's recovery from the COVID-19 pandemic. The study's findings are consistent with those of Holm & Østergaard (2015), who found that similar technology differences have a favorable impact on adaptive resilience in Denmark. Meanwhile, labor productivity and HDI did not significantly affect the recovery of regencies/cities due to the shock of the COVID-19 pandemic.

The finding that ICT can accelerate recovery may exhibit heterogeneity across regions. While urban areas with more advanced infrastructure may experience faster recovery due to higher ICT adoption, rural or lagging regions might benefit less if access to technology and digital skills is limited (Martin, 2012; Martin & Sunley, 2015; Martin et al., 2016). This suggests that the positive effect of ICT on recovery is contingent on the level of regional development and digital readiness. Therefore, targeted policies to improve ICT infrastructure and digital literacy in less developed areas could enhance adaptive capacity and speed up recovery from shocks, ensuring that the benefits of ICT

are more evenly distributed across all regencies/cities (Holm & Østergaard, 2015; Martin & Gardiner, 2019; Masten & Obradovic, 2008).

Evidence from other regions of the world also provides useful insight into how similar patterns emerge in different contexts. Similar to the Indonesian case, regions with high inequality and low ICT adoption tend to exhibit lower resistance and slower recovery from shocks (Castells-Quintana & Royuela, 2017; Geelhoed et al., 2021). Studies in Europe and China have also shown that income inequality, sectoral employment structure, industrial concentration (Herfindahl index), labor productivity, population size, human development, and ICT adoption significantly influence regional resilience (Annoni et al., 2019; Chen et al., 2021; Cuadrado-Roura & Maroto, 2016; Gong et al., 2020). However, Indonesia presents unique features: its demographic distribution, regional disparities in digital development, and heterogeneous industrial structures create distinctive patterns of resilience compared with more developed European or East Asian regions (Kartiasih et al., 2023; Bailey et al., 2020). These observations highlight the importance of context-specific policies, such as strengthening ICT infrastructure in lagging regions and reducing income disparities, while also showing that certain determinants of resilience are consistent across countries.

Based on the preceding discussion, it can be concluded that although resistance and recovery are positively correlated (see Figure 6), the factors that shape each dimension are not identical. Resistance reflects the ability to absorb the initial shock and is therefore more strongly influenced by structural vulnerabilities such as income inequality, population exposure, and sectoral dependence. Regions with high inequality or large populations experienced deeper contractions, indicating that absorptive capacity is primarily determined by pre-shock conditions.

In contrast, recovery reflects adaptive capacity during the reopening period. ICT adoption becomes a more important driver in this phase because digital readiness enables regions to restore economic activity more quickly under new work arrangements. Meanwhile, specialization, which supports resistance, becomes a disadvantage during recovery due to limited diversification. These distinctions demonstrate that enhancing resistance requires reducing underlying structural risks, whereas strengthening recovery requires boosting adaptive capabilities such as ICT readiness and sectoral flexibility.

5. Conclusion

This study provides a comprehensive assessment of regional economic resilience across all 514 regencies and cities in Indonesia during the COVID-19 shock, offering one of the most extensive subnational analyses conducted to date. The descriptive results show clear spatial patterns in labor distribution and resilience outcomes. Regencies and cities in Bali, Java, Kalimantan, Maluku, and West Papua generally display more diversified labor structures, while regions in Sumatra, Sulawesi, and Nusa Tenggara tend to be more specialized. Papua Province exhibits the highest degree of specialization, particularly in agriculture, education, and health services. These structural distinctions help explain why many regencies and cities in Sulawesi, Maluku, and Papua demonstrated strong resistance to the 2020 shock, whereas recovery patterns were more varied; regions in Kalimantan, in particular, recorded the strongest recoverability in 2021 and 2022, while a large share of urban areas across Indonesia showed weaker post-shock recovery.

The econometric analysis further reveals that regional specialization enhances resistance, whereas income inequality, population size, and limited ICT adoption weaken a region's ability to absorb shocks. During the recovery phase, ICT readiness emerges as

a key driver of a faster rebound, while income inequality, population pressure, and the manufacturing labor share continue to hinder recovery. These findings underscore the differentiated mechanisms through which structural characteristics shape both the impact of shocks and the speed of recovery across Indonesia's diverse regions.

Beyond documenting these empirical patterns, the study offers an important contribution to the regional resilience literature by providing the first national-scale analysis of resistance and recoverability linked to inequality, ICT readiness, and sectoral specialization across all Indonesian regencies/cities. This comprehensive coverage allows the study to capture heterogeneity that is often overlooked in analyses focused on selected provinces or major metropolitan areas. The use of resistance–recoverability metrics also deepens the understanding of how structural drivers operate differently in the shock-impact and recovery phases—an aspect that remains underexplored in studies on emerging economies.

These findings carry several policy implications. Central and local governments should collaborate to design operational policy measures aimed at strengthening both resistance and recovery capacity. Reducing income inequality—identified as a consistent constraint to resilience—can be pursued through more accurate and better-targeted social assistance programs based on the Unified Social Welfare Database (DTKS), as well as region-specific wage support schemes for vulnerable workers. Improving ICT readiness requires coordinated investments in backbone digital infrastructure, subsidized internet access in remote regions, and digital literacy programs tailored to local labor markets and MSMEs. In regions with excessive sectoral specialization, policy interventions that promote sectoral diversification, including agro-processing development or strengthening local education and health services, can enhance adaptive capacity and reduce structural vulnerability.

Finally, the study highlights promising directions for future research. More generalizable conclusions require comparative evidence from different economic shocks and broader spatial contexts. Future work could test the robustness of these results using alternative identification strategies, alternative resilience metrics, or dynamic modeling approaches. Deeper investigation into sectoral specialization—particularly the roles of essential and non-essential sectors—would further clarify the pathways through which structural characteristics shape regional resilience trajectories. Such extensions would strengthen the empirical foundation for designing resilience-oriented regional development policies in Indonesia and other emerging economies.

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