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NPI Effectiveness on COVID-19 Infections and its Impact on Economy

Aditya Harin Nugroho[1]✉ , [2]Dewa Gede Karma Wisana

[1,2]Demographic Institute, Faculty of Economics and Business, Universitas Indonesia

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Abstract

This paper assesses the effectiveness of movement restriction policies in Indonesia (Non-Pharmaceutical Interventions, NPIs) in controlling COVID-19 transmission and their implications for regional economic performance. By integrating an epidemiological framework with the model of economic growth, this study offers a novel approach to assessing how public health policies interact with economic dynamics at the provincial level in period July 2020 – September 2021. Using district-level data from Kawalcovid19 and MoH, the analysis shows comprehensive restriction packages such as PSBB II and PPKM Level 1-4 were largely ineffective nationwide. In contrast, specific interventions such as stricter school closures, workplace closures, and international travel controls were significantly associated with fewer new cases in Java and Indonesia while did not hinder provincial economic growth. These results underscore the value of targeted, evidence-based measures over broad restrictions. The paper contributes to the literature by bridging epidemiological modeling and economic growth analysis, offering insights for designing pandemic responses that balance health protection and economic stability. The study provides policy insights for managing future pandemics in developing countries with large informal sectors and limited fiscal capacity.

✉ Corresponding author :
Address: Demographic Institute, Faculty of Economics and Business, Universitas Indonesia
E-mail: aditharin.etc@gmail.com

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INTRODUCTION

COVID-19 or Corona Virus (SARS-2) is the global pandemic announced by WHO (World Health Organization) on March 11, 2020. As of mid-march 2022 number of infected patients already reached 458 million cases with a over 6 million deaths (WHO, 2022). The economic impact is massive. Since the first lockdown in Wuhan, the monthly loss in GDP reached 177.413 billion Yuan (You et al., 2020). IMF even mentions the COVID-19 causing the biggest crisis since Great Depression in the 1930s while In Indonesia, it caused the country to face the recession since 1998 with -2,07 GDP growth in 2020 based on BPS data (BPS, 2021).

In contrast to several countries such as Singapore and Malaysia who success to tackle the pandemic at the beginning (Khairulbahri, 2021), GoI (Government of Indonesia) policy in the form of PSBB (Pembatasan Sosial Berskala Besar – Large Scale social Restriction I) are considered wrong and slow to tackle the pandemics (Roziqin, Mas'udi and Sihidi, 2021). Ariawan and Jusril (2020) While PSBB I able to reduce the number of cases, it does not effectively reduce Rt (Effective Reproduction Number), makes the number of cases keep breaking new records after the policy was introduced. Moreover, the failure of policy from the beginning of the pandemics made Indonesia face the second wave of the pandemic at July 2021 with the case peak at 52 thousand new cases (Nugroho and Syarief, 2021). Indicating subsequent policies were less effective in sustaining the decline.

Given the novelty of COVID-19, mistakes are inevitable. The lack of information about this pandemic has made many governments worldwide and WHO astonished by the pandemics impact on population and economy. Therefore, the research which combined the economic approach with the pandemic are encouraged (Avery et al., 2020).

PSBB I is classified as NPI (Non-Pharmaceutical Interventions). In Indonesia, this policy package includes the restriction of movement to school, workplace, prayer, gathering, and international movement. During the period until we wrote this paper, this policy package followed by PSBB II, PSBB Transition, PPKM (Pemberlakukan Pembatasan Kegiatan Masyarakat-Community Restriction) Micro, and the latest PPKM Level 1-4 or usually called by PPKM emergency.

Even though the NPI is recommended by WHO to tackle the influenza type pandemic (WHO, 2019), the effectiveness of this policy around the world is still not clear (Bou-Karroum et al., 2021; Khairulbahri, 2021). From an economic perspective, the policy is still important since the economy cannot reach pareto optimum due to the economic agent not internalized the negative externality of COVID-19 on its decision and this decision expected to negatively impact the economy in short term (Eichenbaum et al., 2020) but not worsen medium-run economic outcomes (Correia, Luck and Verner, 2022). Specifically, for NPI, the negative impact was expected coming from the purpose of this policy to lower consumption and working hours for limiting the interaction between economic agent (Eichenbaum et al., 2020) and several recent studies found that the negative impact of this type of policy are preminent to economy in term of GDP (Acemoglu et al., 2021; Boyd et al., 2025). Therefore, this research will provide more information about the effectiveness of such policy to reduce the case and its impact to economy with study case of Indonesia since finding the balance between those two both will provide better recommendation.

Although Indonesia has been among the countries most severely affected by COVID-19 in Southeast Asia, few studies have assessed the effectiveness of NPIs at the national level. Existing research has largely focused on specific regions (e.g., Jakarta or parts of Java) or on single policies such as PSBB or Emergency PPKM (Hikmahwati et al., 2020; Suraya et al., 2020; Toharudin et al., 2021; Nanda et al., 2022; Prasiska, Muhlis and Megatsari, 2022), leaving limited understanding of broader impacts.

The study contributes to the literature in three ways. First, it provides empirical evidence on the heterogeneous effectiveness of NPIs across Indonesian, highlighting which measures were most effective in reducing infections. Second, by linking epidemiological shocks with the MRW framework, it advances the analytical understanding of how public health interventions interact with regional growth. Third, the paper offers policy insights for designing pandemic responses that balance health and economic resilience.

The rest of this paper is structured as follows. Section 2 explains our data and econometric method. Section 3 describes our analysis and discusses the result. Lastly, section 4 concludes the paper.

RESEARCH METHODS

This study employs a multi-stage empirical strategy to assess the effectiveness of movement restriction policies on both epidemiological and economic outcomes in Indonesia. The methodological framework integrates three complementary econometric approaches: Regression Discontinuity in Time (RDiT), Fixed Effect (FE) panel estimation, and an extended Mankiw–Romer–Weil (MRW) growth model. Together, these methods enable robust inference by linking causal effects on infection dynamics observed from daily cases of COVID-19 with provincial economic performance. Each model serves a distinct analytical purpose but also builds on the results of the previous stage to ensure internal consistency.

To capture the number of daily cases of COVID-19, we use the data from Kawalcovid-19 and ministry of Health collected by (Harto, 2021) from July 2020 to September 2021. The number of daily cases in every district is generated from the difference of accumulated daily cases for each day. Moreover, to reduce the bias due to the different timing of entry (Bappenas, 2021) and to capture incubations time which is expected around seven days in Indonesia (Ariawan and Jusril, 2020), we transform the daily case into a 7-days moving average (4 forward and 2 backward). Since the purpose of the movement restriction policy are to restrict the population movement, and we found the important correlation between movement and COVID-19 infections (Sá, 2020; Auliya and Wulandari, 2021), we also include movement range data from Facebook as another dependent variable in the same period. This data is encouraged to use since it has a clear methodological explanation and provides more data to the district level (Khoirunurrofik, Abdurrachman and Putri, 2022).

The first stage employs RDD (Regression Discontinuity Design) with time as running variable or usually called by RDiT (Regression Discontinuity in Time) (Hausman et al., 2017) method to find the causality of NPI in the form of policy package PSBB II and PPKM level 1-4 to the movement and COVID-19 daily new case. Those two policies are analyzed due to several reasons. 1) PSBB I have selection bias due to the policy being decided by Ministry of Health based on economic factors 2) Other policies such as PSBB transisi and PPKM mikro are not as strict as the analyzed policy (Appendix, 6). The basic framework of this model is based (Liu et al., 2021), while the general framework of the use of RDD on panel data can be found on (Lee and Lemieux, 2009). We employ the following model:

$$Y_{it} = ai + B_1 L_{it} + f(d_{it}) + \boldsymbol{\varepsilon} it \quad \text{..................... (1)}$$

The i used in this research are district in Indonesia while the t is days. Running variable (dit) used in this model is date before and after policy PSBB II (13 September 2020 in Jakarta) and PPKM Level 1-4 (3 July 2021 in Java and Bali and 6 July Outside Java and Bali) introduced centered into the number of days before and after. L is treatment variable based on cut off when the policy introduced. Moreover, to isolate the impact around the policy, we limit the observations for PSBB II two months before and after policy implemented while for PPKM Level 1-4 three months before and after policy implemented since the policy implemented longer.

To validate the model for PSBB II and PPKM Level 1-4 we employ two tests. First, density test using local polynomial density estimator based on Cattaneo, Jansson and Ma (2020) which testing whether the regression line continuous around the cut off and each observation cannot manipulate the running variable. Second, bandwidth consistency test which due to Lee and Lemieux (2009) the result with different specifications with alternative bandwidth are more reliable than the model which sensitive with the bandwidth.

The second stage uses a district-level Fixed Effect (FE) model to identify which specific policy components most effectively reduce infections and mobility. The policy type classified by the OxCGRT (The Oxford COVID-19 Government Response Tracker) database so it can be fairly compared with other research use the same data. Variable used in this research are adopted from Chen et al. (2020) but with different approach. Instead using the variable as dummy, we used the score to identify the policy and employ fixed effect or random effect model. The model used:

$$Y_{it} = a_{it} + \beta' policy + \gamma' X_{it} + d_i + u_{it} \text{ ....(2)}$$

The dependent variable used in this model is same with the RDiT model. policy is vector of covariates for several policy analyzed in this research. The policy analyzed are based on Chen et al. (2020) but focusing only the movement restriction policy including school closing, workplace closing, restriction on gathering and public transportation closing. Moreover, we also include international travel control policy due to the fact that no variant of concern are found in Indonesia. X is vector of control variable including number of youth worker, stay at home duration, household size and dummy variant of concern when the dependent variable used are daily new case. The dependent variable is the population movement, stay-at-home duration and COVID-19 variant are removed since there is a potential of multicollinearity between stay-at-home duration and population movement and the COVID-19 variant assumed not directly contribute to the movement.

In the third stage, Mankiw–Romer–Weil (MRW) growth model is estimated at the provincial level to explore the economic implications of NPIs. The model adapted from Aspiansyah and Damayanti (2019) combined with Chen et al. (2020) model to include NPI as the disruptions for economic growth. Using this combination, we hope to find the indications of which policy can optimally reduce daily case while not contracting the economy. We used the following model:

$$Growth_{it} = a_{it} + B_1 \ln(initialincome)_{it} + B_2 \ln(Human\ capital)_{it} + B_3 \ln(Physical\ capital)_{it} + B_4 Laborgrowth_{it} + \theta' policy_{it} + \gamma' X_{it} + d_i + u_{it} \text{ .... (3)}$$

This model using provincial level analysis with quarterly time frame due to the availability of GDRP growth data thus for the dependent variable, we use YoY constant GDRP growth by quarter at province level. For independent variable we include initial income measured by the GDRP at the same quartal in last year. Meanwhile human capital in this model used percentage of population enroll senior middle school. Physical capital will be measured using percentage of regional gross fixed capital formation to GDRP. Labor growth will be measured by the growth of population. While depreciation of capital and technological growth are held constant at 0.5 as used by Aspiansyah and Damayanti (2019). Meanwhile, different than other variable which using quarterly data, population growth and human capital will using yearly data from Susenas due to limited data.

For the economic disruptions as our variable of interest, we use Chen et al. (2020) framework using policy which based on model 2

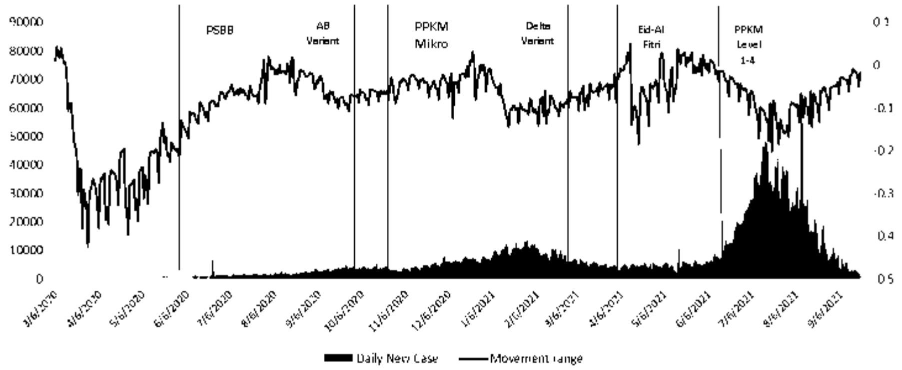


Figure. 1 Daily New Case and Movement Range Juli 2020 – September 2021
Source: Harto (2021) (Processed)

able to reduce the COVID-19 daily new case in the form of the number of days highest level policy implemented at least at one district. But, in the case of workplace closure we use the score 2 due to this intervention mostly implemented in many districts in Indonesia and number of days since first day of infections in the province. We also add Number of days since the first case in province by quarter as additional control variable

The policy used in this research based on the document found in government website. detailed policy document used in this research can be found on appendix 2. Moreover, to adjust with the three models used in this research we transform those policy into several form to meet

several objectives. First, the running variable of number days before and after policy implemented used for RDiT. Second, the policy score adopting the framework of OxCGRT adapted into district level. The framework of creating this variable can be found in appendix 1, 2, 3 and 4. Third, number of days the policy implemented based on policy score at least in one of the districts in quarterly. Detailed description for the variable and data used in this research can be found on Appendix 9.

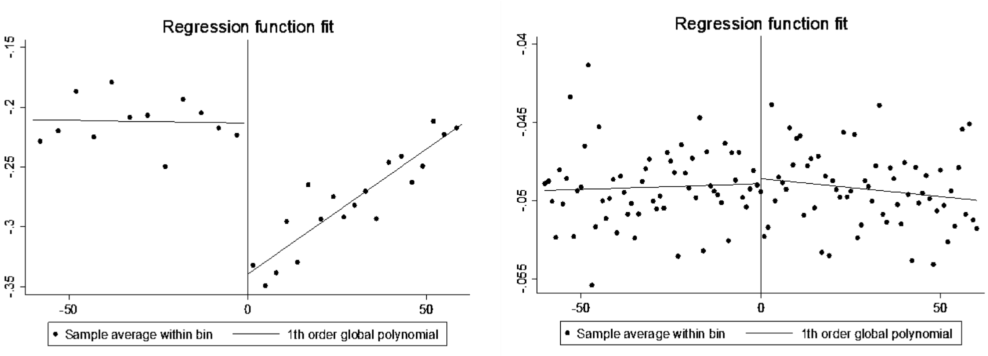
RESULTS AND DISCUSSION

This section will provide descriptive analysis and the result of several model employed in previous section. We begin this section with the description of the dependent variable used in this research. As seen on the Figure 1. The number of new COVID-19 cases during the observation period repeatedly reached record highs even after the movement restriction policies were implemented. In addition, the Micro PPKM policy implemented since January 5 was unable to deal with the increase in the number of daily cases that occurred after the delta variant was announced and the increase in population movement caused by Eid. Additionally, Table 2 shows that after the 2nd quarter of 2021, the average population movement increased the number of new cases in the 3rd quarter of 2021. Therefore, it can be assumed that there is a positive correlation between population movement and the increase in the number of new cases of COVID-19 in Indonesia.

Table 2. Quarterly Mean of Daily New Case and Movement Range

Variabel	2020		2021		
	Q3	Q4	Q1	Q2	Q3
	1 Jul - 31 Sep	1 Okt - 31 Des	1 Jan - 31 Mar	1 Apr - 31 Jun	1 Jul - 20 Sep
Daily New Case	1,218	4,831	8,119	6,853	21,072
Movement Range	-0.13	-0.05	-0.08	-0.03	-0.08

Source: Data Processed, 2025



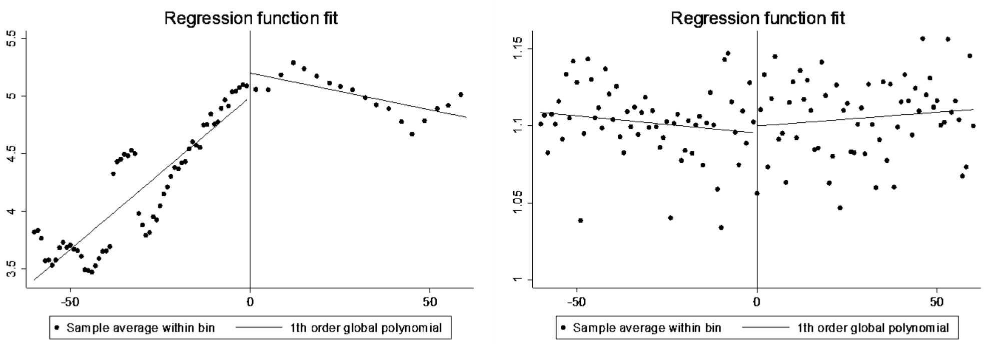
(i) Movement-DKI Jakarta (ii) Movement-Java

Figure 2. RD Plot for Impact of PSBB II and Movement Range in DKI Jakarta and Java
Source: Harto (2021); Facebook Humdata, 2021 (Processed)

Table 3. RDiT for Impact of PSBB II to Daily New Case and Movement Range in DKI Jakarta and Java

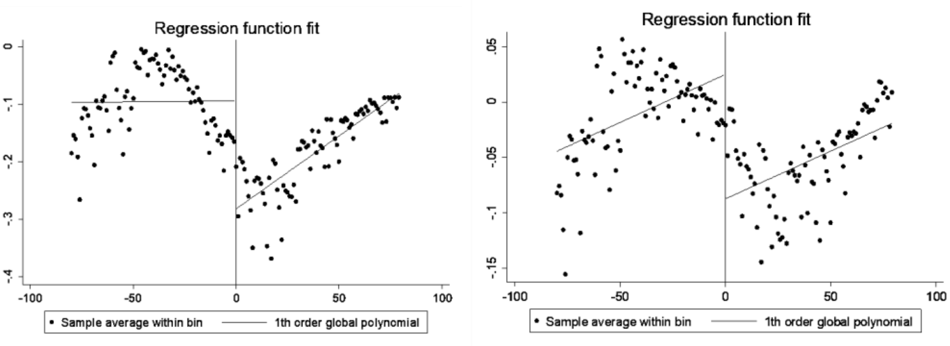
Independent Variable	DKI Jakarta		Java	
	(1) Movement Range	**(2) Daily New Case**	**(3) Movement Range**	**(4) Daily New Case**
PSBB II	-0.0991***	-0.143*	-0.00189	-0.00091
	(0.000)	(0.067)	(0.423)	(0.979)
Number of District	5	5	127	127
Observations	105	95	1521	2223
RDD	Sharp	Sharp	Sharp	Sharp

p-values in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Harto (2021); Facebook Humdata, 2021 (Processed)



(i) Log MA Daily New Case-DKI Jakarta (ii) Log MA Daily New Case-Java

Figure 3. RD Plot for PSBB II Impact to Daily New Case In DKI Jakarta and Java
Source: Harto (2021); Facebook Humdata, 2021 (Processed)



(i) Movement – Java-Bali (ii) Movement-Outside Java-Bali

Figure. 4 RD Plot PPKM Level 1-4 and Movement Range
Source: Harto (2021); Facebook Humdata, 2021 (Processed)

Table 4. RDiT PPKM Level 1-4

Independent Variable	Java-Bali		Outside Java-Bali	
	(1)	(2)	(1)	(2)
	Movement Range	Daily New Case	Movement Range	Daily New Case
PPKM Level 1-4	-0.0566***	0.0574	0.00392	0.0511
	(0.000)	(0.498)	(0.269)	(0.398)
Observations	2921	3429	7803	7225
RDD	Sharp	Sharp	Sharp	Sharp

p-values in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Harto (2021); Facebook Humdata, 2021 (Processed)

The analysis in this section begins by looking at the RD Plot as early identification of a sharp discontinuity between before and after the policy. Based on Figure 2, it can be concluded that the initial identification shows an effect of the PSBB II policy on population movement in both districts in DKI Jakarta and districts throughout Java. But the estimation still needed to prove the real correlation.

The estimation results from the RDiT of PSBB II to population movement and COVID-19 infections are shown in Table 3. Based on the estimation results, we found that in DKI Jakarta, the implementation of the PSBB II policy reduced movement by about 10 percent. This result in line with Khoirunurrofik, Abdurrachman and Putri (2022) showing that the policies implemented have succeeded in meeting their objectives of limiting the population movement. In line with this, the implementation of PSBB II has also succeeded in reducing the number of daily new cases proxied through the running average of COVID-19 cases per 7 days by an average of 14 percent. In Jakarta, this outcome was largely attributable to the well-coordinated policies of the provincial government, particularly through the implementation of Governor Regulation No. 33 of 2020, as well as the relatively high level of knowledge, support, and compliance among residents regarding the enforcement of PSBB II (Hikmahwati et al., 2020). Suggesting that differences in human capital levels could affect the internalization of COVID-19's negative externalities.

In addition, Figure 3 illustrates the impact of PSBB II across all districts on the island of Java, following the discontinuity identified in the RD plot. The estimation results indicate that the PSBB II policy did not have a significant effect on any of the dependent variables. Although the number of cases in DKI Jakarta was substantially higher than in other regions of Indonesia, the implementation of PSBB II in the province was not sufficient to reduce COVID-19 cases at the national level. According to (Suraya et al., 2020), this was primarily due to a lack of compliance in several regions, particularly in West Java and East Java showing the different of level of human capital could impact the internalization of COVID-19 negative externality.

The next policy analyzed in this section is the PPKM (Levels 1–4). The results of the RD plot assessing its impact on population movement are presented in Figure 4. The RD plot suggests that the PPKM Levels 1–4 policy had an effect on population movement and preliminary evidence that the PPKM Levels 1–4 policy contributed to a decline in daily cases.

Table 5. RDiT +7 Days of Eid-Al Fitri and Announcement of Delta Variant to Daily New Case

	T: +7 Days of Idul Fitri		T: Announcement of Delta Variant	
	Outside Java-Bali	Java-Bali	Outside Java-Bali	Java-Bali
RD Estimates	-0.113	0.175*	0.0872*	0.149*
	(0.079)	(0.035)	(0.019)	(0.024)
Observations	6069	3175	12427	4953
RDD	Sharp	Sharp	Sharp	Sharp

p-values in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Harto (2021); Facebook Humdata, 2021 (Processed)

To prove the early identification, table 4 shows the estimation result of RDiT for PPKM Level 1-4 impact to population movement and COVID-19 infection. The estimation show the policy only significantly decreases the population movement in Java and Bali. Furthermore, the correlation between PPKM Level 1-4 with the daily case turned out not significant both in Java-Bali and Outside Java-Bali even after three months of its implementation.

This result is surprising since in Indonesia, PPKM Level 1-4 is considered one of the most successful policies by GoI. At the international level, similar policies have proven less effective due to low public compliance in developing countries, which is attributed to high levels of informality, limited fiscal capacity, weak healthcare infrastructure, and a relatively younger population structure (Alon et al., 2020; Zhirnov and Adeel, 2025) These factors collectively serve as constraints on governments' ability to induce behavioral changes.

In local context, several reasons can explain the result. First, the lack of observation period causing the effectiveness of the policy until 20 September 2021 cannot be seen. It is in line with WHO Situation Report for Indonesia No.72, which reporting until 15 September 2021 the COVID-19 infections outside Java and Bali, especially in Borneo islands are still high. Second, the incoming wave of Delta Variant and Eid-Al Fitri holiday. To prove the argument, we employ RDiT using +7 Eid-Al Fitri holidays and the timing of Delta Variant announced by WHO. Table 5 shows the the estimated effects of Eid Al Fitri and announcement of delta variant impact on COVID-19 infections in Java-Bali and Outside Java and Bali. The result shows both phenomenon are causing the increase of daily new cases of COVID-19 in Java-Bali. But, outside Java-Bali, only delta variant causing the increase of the daily new case. This phenomenon can be attributed to the post–Eid al-Fitr period, during which mass homecoming (mudik) occurs among a large share of the population, which has been shown to increase the number of COVID-19 cases in major mudik destination areas such as West Java, Yogyakarta, Banten, and Central Java (Veruswati et al., 2021). Third, the result is in line with Karnadi & Kusumahadi (2021), showing that the more stringent policy showed by stringency index in contrary increase the COVID-19 case.

The model then validated using Local Polynomial Density Estimator Test showing no manipulation and the regression line are continued around the cut-off (Appendix 10). Moreover, the bandwidth consistency test shows the coefficient result are consistent with different bandwidth both for PSBB II in DKI Jakarta and PPKM Level 1-4 in Java and Bali (Appendix 7).

Although we found no causality between policy package in the form of PSBB II and PPKM Level 1-4, Table 6 shows the result of the Fixed effect estimation of model to find the specific type of movement restriction policy considered effective to reduce COVID-19 daily new case. As we mentioned before, the policy classifications provided by OxCGRT while the framework to generate the policy variable at the district level explained by Appendix 1-4. Fixed effect used due to the Hausman test result rejected the null hypothesis (Appendix 6).

The result shows that the more stringent policy on workplace closing, public transportation closing, restriction on gathering, and international travel control significantly reduce population movement in Java Island and Indonesia. Still, school closing policy to close all levels of education increased the population movement.

After we know most of the policy successfully decreases population movement, column 2 of Table 6 shows the estimation result of the second to the daily new case of COVID-19. Interestingly, despite more stringent school closing positively correlating with the population movement, the policy has a negative and significant correlation with daily new cases in Java Island and Indonesia. We also find the same result in workplace closing and international travel control.

The result in line with Chen et al. (2020) also finds that school closing and workplace closing effectively reduce COVID-19 infections. Meanwhile, more stringent policy on public transportation closing and gathering restriction correlate positively and significantly with the daily new case. The result on international travel control, in line with the fact that the variant of concern never found in Indonesia (WHO, 2023) thus assumed increasing number of case coming from the imported one. Moreover, we found that dummy variables of the announcement of alfa, beta, and delta variant are significant to increase the number of daily new cases. Furthermore, similar to the RDiT model result, this model also proves that some policies effectively reduce population movement not always able to reduce the COVID-19 daily new case.

In addition, since the fixed-effect model was estimated using robust variation cluster error (vce), we assume there is no heteroskedasticity problem. Additionally, based on the Appendix 5 we found no perfect multicollinearity among the independent variable. Therefore, we can conclude that the models fit the BLUE assumption.

Overall, these results highlight an important insight reducing mobility alone does not guarantee lower infection rates and the result in Indonesia also align with cross-country studies showing that targeted interventions often outperform broad lockdowns in term of epidemiological in the developing countries settings (Alon et al., 2020). In Indonesia, the relatively stronger results for school closures and international travel controls likely reflect the ability of these policies to interrupt high-risk contact networks. In contrast, general restrictions on gatherings and transportation may have displaced rather than eliminated social interactions.

Economic Effects

The extended MRW growth model connects these epidemiological dynamics with provincial economic outcomes. Table 7 give estimation about how selected NPI correlated with GDRP. The result shows that that the number of days workplace closures/work from home (non-essential sector still operating) implemented are negatively correlates with economic growth. Showing that some policy are expected to negatively impact the economy in short term expecially due to limiting the interaction of labor as economic agent as mentioned by Acemoglu et al. (2021).

Contrary to that result, the number of days school closure in every level of education implemented positively correlated with quarterly GDRP growth from Q3 2020 to Q3 2021. Moreover, the total closure of international borders also shows similar result. Moreover, the finding for other variable in physical capital represented by percentage of gross fixed capital formation to GDRP, initial income and human capital represented by percentage of Senior Middle School student still in line with Aspiansyah and Damayanti (2019) result on basic MRW model.

In the case of international border closure, the positive correlation between international border-closure policies and provincial economic growth in Indonesia caused by limited number of provinces rely heavily on international tourism. This is consistent with findings from previous studies showing that, while the overall impact of the pandemic was negative, its effects were spatially heterogeneous (Akita and Alisjahbana, 2023). Many provinces highly dependent on tourism such as Bali and Riau Island experienced substantial economic contractions, whereas non-tourism-dependent regions were less directly affected, though they may still have been impacted indirectly through inter-regional linkages (Hutchinson and Negara, 2021; Pham and Nugroho, 2022; Akita and Alisjahbana, 2023).

Regarding the school closure, although schools at all levels were closed, there was no discernible effect of the crisis on public education spending in Indonesia, which likely helped sustain economic growth in the education sector (World Bank, 2020). However, household education expenditures contracted, as resources were reallocated to other, more essential needs during the pandemic (World Bank, 2020). Moreover, Further supporting this interpretation, Deb et al. (2022) find that school closures, as a form of NPI, were associated with relatively low short-term economic costs.

Table 6. Fixed-Effect Model Policy Impact on Movement Range and Daily New Case

Independent Variable	Indonesia		Java	
	(1)	(2)	(3)	(4)
	Movement Range	Daily New Case	Movement Range	Daily New Case
School closing				
2. Require closing (only some levels or categories, e.g. just high school, or just public schools)				
3. Require closing all levels	0.0364***	-0.190***	0.0453***	-0.194***
	(0.000)	(0.000)	(0.000)	(0.000)
Workplace closing				
2. require closing (or work from home) for some sectors or categories of workers				
3. require closing (or work from home) all-but-essential workplaces (e.g. grocery stores, doctors)	-0.0203***	-0.436***	-0.0118*	-0.398***
	(0.000)	(0.000)	(0.029)	(0.000)
Close public transportation				
0. No measures				
1. Recommend closing (or significantly reduce volume/route/means of transport available)	-0.0537***	0.390***	-0.0773***	0.434***
	(0.000)	(0.000)	(0.000)	(0.000)

Independent Variable	Indonesia		Java	
	(1)	(2)	(3)	(4)
	Movement Range	Daily New Case	Movement Range	Daily New Case
Restrictions on gatherings				
3. Restrictions on gatherings between 11-100 people				
4. Restrictions on gatherings of 10 people or less	-0.0338***	0.340***	-0.0518***	0.417***
	(0.000)	(0.000)	(0.000)	(0.000)
International Travel Control				
2. Quarantine arrivals from high-risk regions				
3. Ban on arrivals from some regions	-0.0104***	-0.394***	0.0115***	-0.552***
	(0.000)	(0.000)	(0.000)	(0.000)
4. Ban on all regions or total border closing	-0.0263***	-0.645***	-0.00113	-0.912***
	(0.000)	(0.000)	(0.589)	(0.000)
Log Worker age 20-49	0.0102	-0.0772	0.0332***	-0.376
	(0.059)	(0.472)	(0.000)	(0.118)
Stay at home duration		50.89***		59.41***
		(0.000)		(0.000)
Stay at home duration x household size		-10.18***		-11.97***
		(0.000)		(0.000)
Dummy Delta Variant		0.105***		0.220***
		(0.000)		(0.001)
Dummy Alpha Beta Variant		0.317***		0.137*
		(0.000)		(0.017)
Constant	-0.147*	0.0258	-0.510***	3.961
	(0.025)	(0.984)	(0.000)	(0.208)
District Fixed effect	Yes	Yes	Yes	Yes
Observations	185952	185952	56769	56769
Adj R^2	0.072	0.278	0.198	0.437

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source: Harto (2021); Facebook Humdata, 2021; BPS – Indonesia, 2020-2021 (Processed)

Table 7. MRW Model of Economic Growth

Independent Variable	GDRP Growth
Number of days implementation of school closure on all level (Score 3)	0.164***
	(0.001)
Number of days implementation of workplace closure/WFH with non-essential sector allowed to operate	-0.527***
	(0.001)
Number of days implementation of total border closure	0.309***
	(0.004)
Ln Initial income	-42.39***
	(0.002)
Ln Physical Capital	-5.614
	(0.181)
Ln Labor Growth	-0.109
	(0.827)
Ln Human capital	25.72***
	(0.009)
Number of days since the first case	-4.475***
	(0.008)
Constant	1633.5***
	(0.000)
Observations	121
Adjusted R^2	0.830

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: OXCGrT, 2021; BPS – Indonesia, 2020-2021; covid19.go.id, 2021 (Processed)

Nevertheless, limited immediate economic disruption does not eliminate the potential for substantial long-term effects. School closures generated considerable learning losses defined as reductions in knowledge, skills, or academic progress resulting from prolonged interruptions in schooling (Huong and Jatturas, 2020) as documented across countries (Dela Cruz et al., 2025; Jakubowski, Gajderowicz and Patrinos, 2025). In Indonesia, this policy related with loss of 0.9 years of learning and 25 points of PISA reading scores (Afkar and Yarrow, 2021). Moreover, evidence from meta analysis showing learning losses being largest in mathematics (Wisenocker, et al. 2025) and disproportionately among students from lower socioeconomic backgrounds (Pena, Volante and De Witte, 2025).

From a macroeconomic perspective, these disruptions are expected to place downward pressure on long-run economic growth. Learning losses reduce future labor productivity and, consequently, future output (Hanushek and Strauss, 2025). Projections indicate that national GDP could fall below baseline estimates by 0.4–2.1 percent over the long term in the absence of mitigating interventions (Costa et al., 2021; de la Maisonneuve, Égert and Turner, 2023). Specifically, (de la Maisonneuve, Égert and Turner, 2023) estimate that the cumulative effect of the COVID-19 school closures could lower GDP approximately 45 years later due to the reduced human capital accumulation of affected cohorts.

Based on this finding, we found the early identification that a more stringent policy on school closing and international travel control is the optimal policy to control COVID-19 daily new case without sacrificing the economic growth. Showing that as mentioned by Hur (2022), it is possible to simultaneously improve public health and economic outcomes, suggesting that debates regarding a supposed tradeoff between economic and health objectives may be misguided. The result also in line with (Acemoglu et al., 2021) where targeted policy to reduce interactions between groups minimize economic losses.

Overall, the results indicate that not all containment measures exert uniform effects on provincial economic performance. While workplace closures tend to suppress short-term economic growth by reducing productive labor interactions, policies such as school closures and international travel restrictions more limiting virus transmission without proportionally harming economic activity. This variation underscores the importance of policy composition and regional economic structure in shaping the net impact of NPIs.

CONCLUSION

This study examined the effectiveness of Non-Pharmaceutical Interventions in mitigating COVID-19 transmission and their implications for Indonesia's provincial economic performance. By integrating the RDiT approach, Fixed Effect estimation, and the MRW growth model, the analysis bridges the gap between epidemiological model and economic growth.

The findings confirming our hypothesis indicate the causal relationship between the PSBB II and PPKM 1-4 as broad policy packages were not uniformly effective in reducing daily COVID-19 cases in Indonesia two or three month after implementation despite it effectively reduce the population movement.

In addition, based on the fixed-effect model, targeted policy specifically tightening rules for school closures, workplaces closure and control of international movements were policies which can reduce the number of new cases daily. The importance of controlling international movements is supported by the fact that none of the variants of concern for COVID-19 came from Indonesia, and there is a positive correlation between the announcement of a new variant of COVID-19 by WHO and the number of daily cases of COVID-19, so it can be concluded that the entry of the variant was caused by case import.

In addition, the integration of economic model in the analysis indicate that the policy is also good to maintain the balance between economic growth at the provincial level along with school In addition, based on the fixed-effect model, targeted policy specifically tightening rules for school closures, workplaces closure and control of international movements were policies which can reduce the number of new cases daily. The importance of controlling international movements is supported by the fact that none of the variants of concern for COVID-19 came from Indonesia, and there is a positive correlation between the announcement of a new variant of COVID-19 by WHO and the number of daily cases of COVID-19, so it can be concluded that the entry of the variant was caused by case import. In addition, the integration of economic model in the analysis indicate that the policy is also good to maintain the balance between economic growth at the provincial level along with school closures. The study provides policy insights for managing future pandemics in developing countries with large informal sectors and limited fiscal capacity to simultaneously improve public health and economic outcomes. Moreover, this also emphasize the importance of multi-ministry coordination during the pandemics to achieve those results.

Nonetheless, several limitations must be acknowledged. COVID-19 data from Kawalcovid19 and the Ministry of Health may suffer from underreporting, while Facebook mobility data could overrepresent urban and digitally connected populations. The temporal coverage, ending in September 2021, limits analysis of later pandemic phases and the impact of vaccinations. Further research should be considering better indicators such as Effective Reproduction Number to better represent the infection rate of Covid-19 and also the impact of NPI while the vaccinations are massively introduced.

REFERENCES

Acemoglu, D., Chernozhukov, V., Werning, I. and Whinston, M.D., 2021. Optimal Targeted Lockdowns in a Multigroup SIR Model. *American Economic Review: Insights*, 3(4), pp.487–502. https://doi.org/10.1257/aeri.20200590.

Afkar, R. and Yarrow, N., 2021. *Rewrite the future: How Indonesia's education system can overcome the losses from the COVID-19 pandemic and raise learning outcomes for all*.

Akita, T. and Alisjahbana, A.S., 2023. The Initial Impacts of the COVID-19 Pandemic on Regional Economies in Indonesia: Structural

Changes and Regional Income Inequality. *Sustainability (Switzerland)*, 15(18). https://doi.org/10.3390/su151813709.

Alon, T., Kim, M., Lagakos, D. and Vanvuren, M., 2020. *How Should Policy Responses to the COVID-19 Pandemic Differ in the Developing World?*

Ariawan, I. and Jusril, H., 2020. *COVID-19 in Indonesia: Where Are We?* [online] *Acta Med Indones-Indones J Intern Med* •, Available at: <https://covid19.go.id/peta-sebaran2020>.

Aspiansyah, A. and Damayanti, A., 2019. Model Pertumbuhan Ekonomi Indonesia: Peranan Ketergantungan Spasial. *Jurnal Ekonomi dan Pembangunan Indonesia*, [online] 19(1), pp.62–83. https://doi.org/10.21002/jepi.2019.04.

Auliya, S.F. and Wulandari, N., 2021. The Impact of Mobility Patterns on the Spread of the COVID-19 in Indonesia. *Journal of Information Systems Engineering and Business Intelligence*, 7(1), p.31. https://doi.org/10.20473/jisebi.7.1.31-41.

Avery, C., Bossert, W., Clark, A., Ellison, G. and Ellison, S.F., 2020. An economist's guide to epidemiology models of infectious disease. *Journal of Economic Perspectives*, 34(4), pp.79–104. https://doi.org/10.1257/JEP.34.4.79.

Bappenas, 2021. *Studi Pembelajaran Penanganan COVID-19 Indonesia*. [online] Available at: <https://perpustakaan.bnpb.go.id/bulian/index.php?p=show_detail&id=1999> [Accessed 15 April 2024].

Bou-Karroum, L., Khabsa, J., Jabbour, M., Hilal, N., Haidar, Z., Abi Khalil, P., Khalek, R.A., Assaf, J., Honein-AbouHaidar, G., Samra, C.A., Hneiny, L., Al-Awlaqi, S., Hanefeld, J., El-Jardali, F., Akl, E.A. and El Bcheraoui, C., 2021. *Public health effects of travel-related policies on the COVID-19 pandemic: A mixed-methods systematic review*. *Journal of Infection*, https://doi.org/10.1016/j.jinf.2021.07.017.

Boyd, M., Baker, M.G., Kvalsvig, A. and Wilson, N., 2025. *Impact of Covid-19 Control Strategies on Health and GDP Growth Outcomes in 193 Sovereign Jurisdictions*. https://doi.org/10.1101/2025.04.08.25325452

BPS, 2021. *Pertumbuhan Ekonomi Indonesia Triwulan IV 2020 No.13/02/Th. XXIV*. Jakarta.

Chen, L., Raitzer, D., Hasan, R., Lavado, R. and Velarde, O., 2020. *What Works to Control COVID-19? Econometric Analysis of a Cross-Country Panel*. [online] Manila, Philippines. https://doi.org/10.22617/WPS200354-2.

Correia, S., Luck, S. and Verner, E., 2022. Pandemics Depress the Economy, Public Health Interventions Do Not: Evidence from the 1918 Flu. *The Journal of Economic History*, 82(4), pp.917–957. https://doi.org/10.1017/S0022050722000407.

Costa, V., Daniela, Maddison, E. and Wu, Y., 2021. *COVID-19 Learning Loss: Long-run Macroeconomic Effects Update*.

Dela Cruz, N.A., Adona, A.J., Molato-Gayares, R. and Park, A., 2025. Learning loss and recovery from the COVID-19 pandemic: A systematic review of evidence. *International Journal of Educational Development*, 115, p.103271. https://doi.org/10.1016/j.ijedudev.2025.103271.

Deb, P., Furceri, D., Ostry, J.D. and Tawk, N., 2022. The Economic Effects of COVID-19 Containment Measures. *Open Economies Review*, 33(1), pp.1–32. https://doi.org/10.1007/s11079-021-09638-2.

Eichenbaum, M.S., Rebelo, S., Trabandt, M., Alvarez, F., Atkeson, A., Barlevy, G., Ciocchini, F., Cornwall, W., Cusolito, A., Jaganathan, R., Kraay, A., King, M., Manski, C., Romer, P., Simsek, A. and Strongin, S., 2020. *THE MACROECONOMICS OF EPIDEMICS*. [online] Available at: <https://tinyurl.com/ERTcode>.

Hanushek, E.A. and Strauss, B., 2025. United States: The Size and Variation of the Pandemic Learning Losses. pp.189–203. https://doi.org/10.1007/978-3-031-69284-0_13.

Harto, W., 2021. *District Data COVID in Indonesia: Vaccine and COVID*. [online] Available at: <https://github.com/akirawisnu/COVID-District-ID> [Accessed 9 September 2025].

Hausman, C., Rapson, D.S., Anderson, M., Auffhammer, M., Borenstein, S., Cattaneo, M., Davis, L., Holland, S., Kellogg, R., Miller, D. and Smith, J., 2017. *Nber Working Paper Series Regression Discontinuity In Time: Considerations For Empirical Applications*. [online] Available at: <http://www.nber.org/papers/w23602>.

Hikmahwati, *, Sangadji, E., Roro, R. and Utami, M., 2020. *Impact Analysis of the Large-Scale Social Restrictions (PSBB) Policy Implementation in Jakarta*.

Huong, L.T. and Jatturas, T.N., 2020. *The COVID-19 induced learning loss – What is it and how it can be mitigated?*

Hur, S., 2022. The Distributional Effects of COVID-19 and Optimal Mitigation Policies. *Federal Reserve Bank of Dallas, Globalization Institute Working Papers*, [online] 2020(400). https://doi.org/10.24149/gwp400r4.

Hutchinson, F.E. and Negara, S.D., 2021. The Riau Islands and its Battle with COVID: Down but not Out.

Jakubowski, M., Gajderowicz, T. and Patrinos, H.A., 2025. COVID-19, school closures, and student learning outcomes. New global evidence from PISA. *npj Science of Learning*, 10(1), p.5. https://doi.org/10.1038/s41539-025-00297-3.

Khairulbahri, M., 2021. Lessons learned from three Southeast Asian countries during the COVID-19 pandemic. *Journal of policy modeling*, 43(6), pp.1354–1364. https://doi.org/10.1016/j.jpolmod.2021.09.002.

Khoirunurrofik, K., Abdurrachman, F. and Putri, L.A.M., 2022. Half-hearted policies on mobility restrictions during COVID-19 in Indonesia: A portrait of large informal economy country.

Transportation research interdisciplinary perspectives, 13, p.100517. https://doi.org/10.1016/j.trip.2021.100517.

de la Maisonneuve, C., Égert, B. and Turner, D., 2023. Quantifying the Macroeconomic Impact of COVID-19-Related School Closures through the Human Capital Channel. *Economies*, 11(12), p.289. https://doi.org/10.3390/economies11120289.

Lee, D. and Lemieux, T., 2009. *Regression Discontinuity Designs in Economics*. Cambridge, MA. https://doi.org/10.3386/w14723.

Liu, S., Ermolieva, T., Cao, G., Chen, G. and Zheng, X., 2021. Analyzing the Effectiveness of COVID-19 Lockdown Policies Using the Time-Dependent Reproduction Number and the Regression Discontinuity Framework: Comparison between Countries. In: *The 7th International conference on Time Series and Forecasting*. Basel Switzerland: MDPI. p.8. https://doi.org/10.3390/engproc2021005008.

Nanda, R.O., Nursetyo, A.A., Ramadona, A.L., Imron, M.A., Fuad, A., Setyawan, A. and Ahmad, R.A., 2022. Community Mobility and COVID-19 Dynamics in Jakarta, Indonesia. *International Journal of Environmental Research and Public Health*, 19(11). https://doi.org/10.3390/ijerph19116671.

Nugroho, Y. and Syarief, S.S., 2021. Grave Failures in Policy and Communication in Indonesia during the COVID-19 Pandemic. *ISEAS Perspective*, (2021 No. 113).

Pena, J.W.Q., Volante, L. and De Witte, K., 2025. The impact of the pandemic and school closures on non-cognitive characteristics: Evidence from PISA. *International Journal of Educational Research Open*, 9, p.100489. https://doi.org/10.1016/j.ijedro.2025.100489.

Pham, T. and Nugroho, A., 2022. Tourism-induced poverty impacts of COVID-19 in Indonesia. *Annals of Tourism Research Empirical Insights*, 3(2). https://doi.org/10.1016/j.annale.2022.100069.

Prasiska, D.I., Muhlis, A.N.A. and Megatsari, H., 2022. Effectiveness of the emergency public activity restrictions on COVID-19 epidemiological parameter in East Java Province, Indonesia: An ecological study. *Asian Journal of Social Health and Behavior*, 5(1), pp.33–39. https://doi.org/10.4103/shb.shb_90_21.

Roziqin, A., Mas'udi, S.Y.F. and Sihidi, I.T., 2021. An analysis of Indonesian government policies against COVID-19. *Public Administration and Policy*, 24(1), pp.92–107. https://doi.org/10.1108/PAP-08-2020-0039.

Sá, F., 2020. Socioeconomic Determinants of Covid-19 Infections and Mortality: Evidence from England and Wales. *CEPR Discussion Paper Series*. [online] Available at: <https://api.semanticscholar.org/CorpusID:219527295>.

Suraya, I., Nurmansyah, M.I., Rachmawati, E., Al Aufa, B. and Koire, I.I., 2020. The Impact of Large-scale Social Restriction on COVID-19 Incidence: A Case Study of Four Regions in Indonesia. *Kesmas: National Public Health Journal*, 15(2). https://doi.org/10.21109/kesmas.v15i2.3990.

Toharudin, T., Pontoh, R.S., Caraka, R.E., Zahroh, S., Kendogo, P., Sijabat, N., Sari, M.D.P., Gio, P.U., Basyuni, M. and Pardamean, B., 2021. National vaccination and local intervention impacts on covid-19 cases. *Sustainability (Switzerland)*, 13(15). https://doi.org/10.3390/su13158282.

Veruswati, M., Asyary, A., Darmawansyah Alnur, R. and Guspianto, G., 2021. Correlation between Local Eid-al-Fitr Homecoming (Mudik) with Coronavirus Disease-19 during Ramadhan Season Amidst Large-scale Social Distancing in Indonesia. *Journal of Medical Sciences*, 8(T1), pp.570–573. https://doi.org/10.3889/oamjms.2021.5369.

WHO, 2022. *2021 Annual Report WHO's RESPONSE TO COVID-19*. Geneva.

WHO, 2023. *Historical working definitions and primary actions for SARS-CoV-2 variants*. [online] Available at: <https://www.who.int/publications/m/item/historical-working-definitions-and-primary-actions-for-sars-cov-2-variants> [Accessed 9 September 2025].

World Bank, 2020. *The Impact Of The Covid-19 Pandemic On Education Financing*.

You, S., Wang, H., Zhang, M., Song, H., Xu, X. and Lai, Y., 2020. Assessment of monthly economic losses in Wuhan under the lockdown against COVID-19. *Humanities and Social Sciences Communications*, 7(1). https://doi.org/10.1057/s41599-020-00545-4.

Zhirnov, A. and Adeel, A.B., 2025. The informal economy and the reach of policy interventions: Evidence from the COVID-19 lockdown in India. *Review of Development Economics*, 29(1), pp.247–268. https://doi.org/10.1111/rode.13129.