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Revisiting the Phillips curve for Indonesia: What can we learn from regional data?☆

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A B S T R A C T

This study seeks new empirical evidence of the Phillips curve in Indonesia, an emerging and geographically diversified economy. There are three important contributions from this research. First, applying panel econometric method to exploit regional variation, the study resolves the issue of using on-target national inflation rates that potentially causes weakening inflation-output link. Second, the research examines the relevance of mining industry for output gap measurement at regional level. Third, it highlights the differences in the Phillips curve between the west and east regions owing to their different underlying economic structures. Our estimation using regional data support the validity of the Phillips curve relationship in Indonesia. Backward-looking inflation expectations, exchange rate dynamics and international prices also significantly affect inflation. In addition, the effect of output gap on inflation is larger if the mining sector is excluded from output gap measurement. Finally, we find apparent differences between the west and the eastern regions in the slope of Phillips curve, as well as in the degree of inflation persistence and exchange rate pass-through. The results are robust to alternative specification. Our study adds significantly to the empirical literature on the Phillips curve and have meaningful policy implications.

1. Introduction

The Phillips curve framework that explains the short-run tradeoff between inflation and real economic activities has been used extensively to investigate inflation dynamics. However, some global economic events have led economists to dispute the Phillips curve's validity. For more than a decade since the 2008 Global Financial Crisis, inflation dynamics in many advanced economies like the United States – the U.S. hereafter – have confused economists and policymakers, leading to the term "inflation puzzles." Despite the Great Recession resulting in a significant increase in unemployment, inflation only somewhat decreased ("missing disinflation"). Subsequently, inflation has stayed quiet against loose monetary policy and low unemployment rate during the recovery period until the outbreak of COVID-19 pandemic ("missing reinflation") (Hazell et al., 2022). This weakening relationship between inflation and unemployment, or as echoed by many as the flattening Phillips curve, has cast doubts on the suitability of using the framework to test empirical data in the modern economic era, where most of the estimation results show the absence of the tradeoff between inflation

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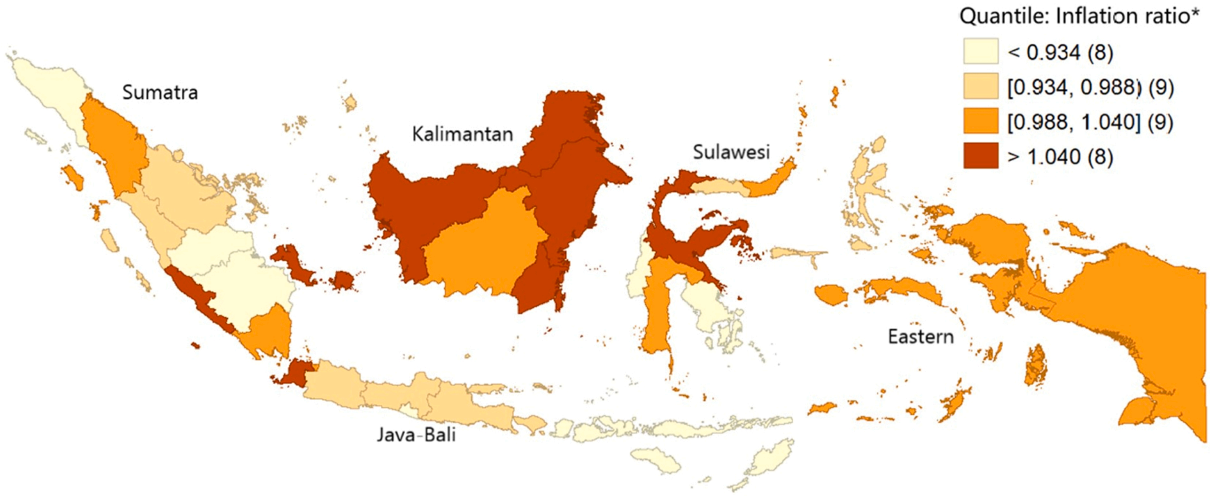

Fig. 1. Province inflation relative to national inflation in Indonesia, average 2012–2019. Note: *Computed by dividing province inflation by national inflation per annum. Number of provinces in parentheses.
Source: Author's calculations.

and unemployment (Watson, 2014; Brainard, 2017). However, following years of moderate to low inflation, the global economy has been presented with a dramatic surge in inflation starting mid-2021 − notably in advanced economies − owing to a significant jump in aggregate demand as economies "reopened" once pandemic-related restrictions were eased. To this extent, a heated debate has emerged among macroeconomists on how to explain the soaring inflation and whether the Phillips curve has steepened. These "ambiguous" Phillips curve relationships exposed by chronological economic events fuel global debate about the Phillips curve framework's relevance in monetary policy formulation. Economists generally agree that the answers to this discussion are empirical and depends on country and time-specific investigation.

Our study aims to contribute to this fascinating debate by investigating the Phillips curve in Indonesia, a large growing economy. More specifically, unlike existing studies that rely on aggregate national data, our study re-examines Phillips curve relationship in a panel framework utilizing provincial-level data from 2012 to 2019.

There are at least three reasons to use regional data in analyzing the Phillips curve in Indonesia. Firstly, since 2005 the central bank of Indonesia has been implementing an Inflation Targeting Framework (ITF) in its monetary policy formulation that focuses on achieving price stability, measured by Consumer Price Index (CPI) inflation.[1] Under ITF, when the central bank achieves its objective of keeping national inflation near its target, the slope of the Phillips curve will appear flatter even if the structural Phillips curve remains strong. In other words, the use of on-target national inflation data could lead to a misleading conclusion where the inflation-output nexus might become less sensitive to the swings in economic activities (Behera et al., 2018). Sub-national data can help solve this endogeneity problem since the central banks do not directly target regional inflation rates (Fitzgerald et al., 2013; McLeay & Tenreyro, 2020).

Secondly, the use of national data could be sub-optimal because it masks the underlying heterogeneity in inflation-output dynamics across Indonesian regions. Fig. 1 illustrates this problem where provinces in Sumatra and Java-Bali regions have lower inflation than the national figure; in contrast, inflation rates in other regions tend to be higher than national inflation. Therefore, employing province panel data provides a different depiction of Indonesia's actual inflation dynamics. Moreover, as suggested by Mehrotra et al. (2007), examining inflation using sub-national data is highly relevant for a geographically large country to accommodate cross-sectional differences in institutions, economic and market structures, and inter-regional economic and trade linkage that can cause inflation differentials.

Thirdly, in addition to gaining larger number of data points, incorporating comparatively higher regional variation into the econometric model could improve the precision in the Phillips curve estimates. While new knowledge in this field has been produced from exploiting sub-national level data in the U.S. and other developed countries, no such effort has been made in the context of Indonesia. In fact, this reasoning is especially pertinent for Indonesia, a geographically diverse country with a myriad of ethnic groups and cultures and diverse natural resource concentrations, and demographic dynamics dispersed across its 34 provinces. Table 1 illustrates the noticeable difference in Indonesian provinces' economic development, particularly between the prosperous west and the less-developed east. The western part of Indonesia (17 provinces in the Sumatra and Java-Bali areas) accounts for over 80% and 82% of the country's population and Gross Domestic Product (GDP), respectively. In contrast, the eastern part accounts for only about 20% of the country's population and GDP. The regional economic characteristics of Indonesian provinces are determined by various

[1] The shift to the ITF is mainly a response of the central bank to the new single-mandate stipulated in Act No. 23 of 1999 concerning Bank Indonesia, as amended by Act No. 3 of 2004 and Act No. 6 of 2009 in Article 7, which is creating and maintaining rupiah stability.

Table 1
Selected economic variables by provinces.

Province	Island	Pop. share to total pop. (%)	GRP share to GDP (%)	GRP non-mining (% to total GRP)	GRP by sector (% to GRP)			Import share to GRP (%)	GRP growth (%, yoy)	Inflation rate (%, yoy)
					Manufacturing	Agriculture	Mining			
West		**80.07**	**81.85**	**91.95**	**20.93**	**17.02**	**8.05**	**17.74**	**5.2**	**4.57**
Aceh	**Sumatra**	1.96	1.28	90.7	6.17	27.1	9.3	1.58	2.94	3.62
North Sumatra		5.46	4.91	98.71	19.43	24.94	1.29	12.15	5.44	4.82
Riau		2.49	4.98	76.45	28.39	24.61	23.55	4.99	2.4	4.56
West Sumatra		2.03	1.56	95.7	10.77	23.33	4.29	5.52	5.57	4.86
Riau Islands		0.78	1.69	84.19	38.08	3.56	15.81	74.76	5.49	4.46
Bangka Belitung		0.54	0.51	86.19	23.01	18.41	13.81	2.75	4.48	5.41
Jambi		1.33	1.38	75.03	11.06	26.09	24.96	1.31	5.44	4.33
Bengkulu		0.73	0.42	96.26	6.2	29.38	3.74	0.72	5.46	5.31
South Sumatra		3.15	2.85	77.98	18.63	18.27	22.02	3.97	5.46	4.09
Lampung		3.18	2.22	93.96	18.02	31.1	6.04	14.83	5.41	4.53
Banten	**Java-Bali**	4.68	4.11	99.26	36.27	5.6	0.74	64.35	5.86	5.27
Jakarta		3.98	16.28	99.81	12.71	0.09	0.2	57.52	6.07	4.67
West Java		18.31	13.49	97.84	43.34	7.76	2.16	12.35	5.59	4.55
Central Java		13.2	8.98	97.88	34.8	13.85	2.13	14.07	5.3	4.36
Yogyakarta		1.44	0.93	99.43	12.94	9.1	0.57	4.3	5.51	4.15
East Java		15.17	14.83	94.87	29.46	11.69	5.13	18.37	5.76	4.34
Bali		1.62	1.44	98.87	6.54	14.37	1.13	8.11	6.28	4.41
East		**19.93**	**18.75**	**84**	**10.61**	**22.16**	**16**	**6.37**	**5.84**	**4.69**
West Kalimantan	**Kalimantan**	1.88	1.25	95.44	16.48	23.25	4.56	6.04	5.29	5.54
Central Kalimantan		0.98	0.88	83.45	15.14	21.4	16.56	1.56	6.54	4.59
South Kalimantan		1.56	1.24	72.78	12.9	14.42	27.21	18.99	4.86	4.91
East Kalimantan		1.34	4.9	50.15	20.45	6.38	49.88	16.86	2.28	4.83
North Kalimantan		0.25	0.55	70.42	9.54	17.24	29.57	2.12	6.35	5.67
North Sulawesi	**Sulawesi**	0.94	0.79	95.01	10.35	20.67	4.99	3.69	6.23	4.94
Gorontalo		0.44	0.25	98.69	4.02	37.1	1.3	2.06	6.9	4.03
Central Sulawesi		1.13	0.92	86.64	9.79	31.17	13.37	11.53	8.77	5.13
West Sulawesi		0.5	0.29	97.78	10.35	39.88	2.2	0.22	7.08	3.93
South Sulawesi		3.33	2.82	94.1	13.91	21.35	5.9	3.73	7.48	4.62
Southeast Sulawesi		0.98	0.82	78.61	6.13	23.7	21.38	11.28	7.31	4.11
West Nusa Tenggara	**Eastern**	1.9	0.91	81.43	4.69	22.93	18.59	3.27	4.5	4.44
East Nusa Tenggara		2.01	0.63	98.57	1.27	28.22	1.43	1.27	5.17	4.33
Maluku		0.66	0.28	96.96	5.39	24.04	3.04	10.36	5.95	4.79
North Maluku		0.46	0.23	89.49	6.23	23.11	10.51	7.96	6.55	4.62
West Papua		0.34	0.58	79	31.81	10.4	21	1.38	4.75	4.55
Papua		1.23	1.43	59.45	2.01	11.44	40.53	5.9	3.34	4.68

Notes: The statistics are the mean of respective variables over the period from 2012 to 2019. GRP and GDP stand for Gross Regional Product and Gross Domestic Product respectively (constant price 2010). Population data is based on Inter-Census Population Survey 2015.
Sources: Author's computation on data published by Indonesian Central Bureau of Statistics.

fundamental factors such as natural resource endowments, climate and topography, and geographic location. In the west, manufacturing industries are vital to the region's economic activities. For example, almost half (43%) of Gross Regional (Domestic) Product (GRP) in West Java and 38% of GRP in Riau Islands are contributed by manufacturing industries. Differently, the primary sector, namely agriculture and mining drives economic activity in the east. Provinces in the west are also more exposed to the effects of changes in international prices, given the relatively higher ratio of imports to GRP (almost 18%) compared to provinces in the east (6.37%). Another interesting observation is the expected relationship between economic growth and inflation. On average, the economic growth of eastern regions is higher than the west, in line with the comparison in the inflation rate between the two regions.

The summary of our findings is as follows. First, results from the main analysis show that the Phillips curve relationship is valid, supporting findings from previous studies and the use of regional data to analyze Phillips curve in Indonesia. Second, the impact of the output gap is larger if the mining sector is excluded from output gap estimation. Third, the slope of the Phillips curve is steeper in the west compared to the east. Our subsequent robustness analysis shows that these results are broadly stable. We present a detailed discussion to support these findings and highlight their implications on policies.

To our knowledge, this study provides the first empirical evidence on the Phillips curve relationship using regional data in geographically diversified Indonesia and further explores the differences between the western and eastern provinces. In addition to contributing to the ongoing international debate on the stability of the Phillips curve, this study also produces new insights for monetary policy implementation in Indonesia.

The remaining part of the paper proceeds as follows. Section 2 briefly reviews recent literature on the Phillips curve relationship. The third section is focused on the methods and data utilized in this study. Section 4 presents and analyzes empirical results across several specifications, and finally, Section 5 concludes.

2. Phillips curve estimation with regional data: the rationale

The Phillips curve is a model that connects the unemployment rate or another measure of aggregate economic activity to a measure of inflation. Fisher (1926) was the first to document such a relationship using data from the U.S. Later study by Phillips (1958) drew much interest. The unemployment rate (unemployment as a percentage of the labor force) negatively correlates with either nominal wage growth or inflation, as per the study. According to Keynesian macroeconomics, the Phillips curve informs policymakers of a selection of tradeoffs over the short-run[2]: they could use demand management measures to increase output and reduce unemployment, but only at the cost of rising inflation.

The literature on estimating the Phillips curve can generally be grouped into two strands. In the first strand, researchers have often used aggregate or national data to identify the Phillips curve. Despite its widespread recognition, several studies from this first group identify a weakening relationship between inflation and real domestic economic activities, causing much discussion about whether the Phillips curve relationship is genuinely structural. Many follow-up studies have also been carried out to explain the instability of the Phillips curve. Among the promising claims is that the Phillips curve estimates differ based on the time period and monetary policy regime. For example, the relationship in postwar U.S. data varies significantly depending on the period studied (see, for example, Atkeson and Ohanian, 2001; Fisher et al., 2002). Another reason is related to the well-anchored inflation expectations, like in the observed disappearing inflation phenomena in the U.S. (Blanchard et al., 2015; Hazell et al., 2022). Looking from the perspective of global factors, Bobeica and Jarocinski (2017) and Kohlscheen and Moessner (2022) argue that globalization could partially explain why domestic inflation and domestic production activities are showing weakening linkage. As more countries are involved in global value chains, the dynamics of global output gaps become more significant in domestic inflation, while the effects of domestic slack become minimized (Auer et al., 2017). Nevertheless, the precise role of global factors, particularly the global output gap, continues to be the point of disagreement. Several studies failed to show convincing empirical evidence or even discover contradictory signs of the global slack coefficient (Béreau et al., 2018).

Aside from the premise of time and policy regime sensitivity, anchored inflation expectations, or the increasing importance of global factors, the use of national-level data − which fails to reflect the structural relationship between inflation and output − may also contribute to the weakening inflation-output nexus. If the aim of monetary policy is to drive national inflation and the central bank is generally successful in achieving the national inflation target, the link between output and inflation may weaken, even in some situations, the relationship is completely disappeared (Fitzgerald et al., 2013). Differently, since the central bank does not primarily target sub-national inflation rates, significant fluctuation in inflation rates across regions is to be expected. Similarly, the output gap at the national level could indicate expanding (or contracting) economy, even when there are negative output gaps in some places (and vice versa). Therefore, the difference in local inflation rates and demand conditions can be taken advantage of and analyzed to gain a better understanding of the inflation-output relationship. Furthermore, as demonstrated by Coen et al. (1999), excessive labor mobility within a country's regions is likely to stifle the regional inflation-output relationship. Indeed, there is a recent attempt to resolve this issue by looking at the possibility of distinguishing unemployment rates into short-term and long-term as a predictor of inflation. However, given the significant historical correlation between the two, at least for the case of the U.S., this advanced hypothesis cannot be adequately explained using national-level data (Kiley, 2015). This argument becomes the root of researchers from the second group, whom in more recent times have incorporated regional variation to estimate the Phillips curve using regional data (Fitzgerald et al.,

[2] In the long-run, as seen from neoclassical perspective, the Phillips curve might be vertical attributable to changes in inflation expectations and supply shocks, implying no tradeoff between inflation and unemployment in the long-run. See, for example, Blanchard (1991) and Cooley and Quadrini (1999) for more detailed discussion.

2013; Kiley, 2015; Babb & Detmeister, 2017; Hooper et al., 2020; Beraja et al., 2019; McLeay & Tenreyro, 2020). Because of its heterogeneity, subnational level data may be more effectively used to examine different hypotheses, for instance, evaluating the shape of the Phillips curve i.e., linear versus non-linear. Scholars have long debated the shape of the Phillips curve and a substantial amount of study has been conducted to identify the possibility of its non-linearity. Under the non-linearity assumption, when output gap moves toward positive trajectory, inflation is more (less) sensitive if the curve is convex (concave). Thus, understanding the shape of the Phillips curve is critical because the consequences to monetary policy may be strongly dependent on the state of the economy (Wimanda et al., 2013; Patra et al., 2021).

Although many scholars meticulously investigate the Phillips curve using national-level data, empirical research that employs regional data for the same purpose is becoming more popular. For example, based on state-level data in the U.S.,[3] Kumar and Orrenius (2016) find strong evidence indicating that the wage-price Phillips curve is non-linear and convex; wage pressure is substantially larger when the unemployment rate falls below the historical average than when it rises above it. Furthermore, Aaronson and Sullivan (2000) and Fitzgerald et al. (2013) discover that the Phillips curve is stable when regional data is used but weakens or becomes inconsistent once using national data. This conclusion supports the view that the structural relationship of the Phillips curve might be weakened or disrupted when the central bank is generally successful in pursuing the national inflation target. However, other studies also emphasize that using national vis-à-vis regional-level data in estimating the Phillips curve is complementary instead of a substitute. For example, Osadcha (2014) finds evidence for the Phillips curve at both the national and state levels. Nevertheless, in addition to incorporating regional variation, another appealing feature from regional-level data is the possibility of exploring the Phillips curve's stability across space. Mehrotra et al. (2007), for example, using provincial-level data in China within a hybrid New Keynesian Phillips Curve (NKPC) framework, conclude that the NKPC is helpful to understand inflation dynamics exclusively only in regions located in coastal areas, since market forces play greater role in their economies and demand pressures are more profound in these regions.

In the Indonesian context, only a few studies have validated the evidence of the Phillips curve relationship, in which all of them use national-level data. These include Wimanda et al. (2011, 2013), and Furuoka et al. (2021). Estimating multiple Phillips curve specifications and several measurements of the output gap using data from 1980:01–2008:12, Wimanda et al. (2011) show that the slope of the Phillips curve at the national level is between 0.038 and 0.168. In terms of the shape, Wimanda et al. (2013) provide evidence on the non-linearity of the Phillips curve relationship in Indonesia, even though the gain in adjusted R-squared is relatively marginal compared to the linear model. Using more recent data from 1997Q1 to 2018Q2, Furuoka et al. (2021) show that the coefficients of the NKPC and hybrid NKPC for Indonesia are 0.219 and 0.235, respectively.

Despite the well-documented regional variation of economic activities, to the best of our knowledge, no studies have examined the Phillips curve using regional data in the Indonesian context. Thus, our study would complement and enrich the current views on the relevance of the Phillips curve for the country.

3. Methods and data

We model actual inflation as a function of both demand and supply factors (Gordon & Stock, 1998; Wimanda et al., 2011; Behera et al., 2018). The domestic output gap is used to capture pricing pressures resulting from domestic demand conditions. On the other hand, as is common in many emerging economies, supply shocks in Indonesia are mostly driven by variations in the nominal exchange rate, changes in global oil prices, and dynamics in foreign price (Ramakrishnan & Vamvakidis, 2002; Affandi et al., 2011; Wimanda et al., 2011; Tirtosuharto & Adiwilaga, 2013). Additionally, supply shock from weather condition also frequently affects inflation in Indonesia, particularly from the price changes in certain food commodities (Alamsyah et al., 2001). Following Behera et al. (2018), our initial step is to estimate the Phillips curve using the static panel specification as follows:

$$\pi_{i,t} = \beta_0 + \beta_1 ygap_{i,t-k} + \beta_2 \Delta NER_{t-k} + \beta_3 \pi_t^{oil} + \beta_4 \log(P_{t-k}^{W}) + \beta_5 \log(rain_{i,t-k}) + \varepsilon_{i,t} \tag{1}$$

where i and k denote the i^{th} province and the k^{th} year-lag, consecutively.

Previous empirical studies have shown the importance of inflation persistence in modeling inflation dynamics (Rudd & Whelan, 2005; Mavroeidis et al., 2014; Wimanda et al., 2011; Behera et al., 2018). We then accommodate this element by augmenting the baseline specification of Eq.1 with lagged inflation, indicating adaptive expectations.[4] As a result, our dynamic panel specification is as follows:

$$\pi_{i,t} = \gamma_1 \pi_{i,t-1} + \gamma_2 ygap_{i,t-k} + \gamma_3 \Delta NER_{t-k} + \gamma_4 \pi_t^{oil} + \gamma_5 \log(P_{t-k}^{W}) + \gamma_6 \log(rain_{i,t-k}) + \xi_{i,t} \tag{2}$$

where $\pi_{i,t-1}$, $ygap$, ΔNER, π^{oil}, P^W, $rain$ sequentially represents the past inflation, output gap, percentage change of nominal exchange rate (Rp/USD),[5] international oil price inflation, world consumer price index, and rainfall condition in each province, while $\varepsilon_{i,t}$ and $\xi_{i,t}$ are the error terms. The lagged inflation ($\pi_{i,t-1}$) is included to account for inflation persistence or backward-looking expectations. This hypothesis implies a link between past and current inflation that goes beyond expectations-based effects. Fuhrer (1997) claims that the Phillips curve's forward-looking component is empirically 'unimportant' for data in the U.S. The author discovers that

[3] The study also examines the Phillips curve using national-level data and finds mixed evidence, in contrast to the robust results from state-level data.

[4] We deviate from Wimanda et al. (2011) that includes forward-looking expectations due to data limitation at the provincial level.

[5] The Rupiah appreciates (depreciates) when its value is positive (negative).

Table 2
Summary statistics.

Variable		Mean	Std. dev.	Min	Max
All provinces, n = 34					
Inflation (%, yoy)	overall	4.63	2.51	0.23	11.91
	between		0.46	3.62	5.67
	within		2.46	0.04	11.35
Output gap, total GRP (%)	overall	0.15	1.85	-12.28	9.4
	between		0.24	-0.76	0.6
	within		1.84	-11.83	10.31
Output gap, non-mining GRP (%)	overall	0.15	0.92	-3.18	4.39
	between		0.16	-0.21	0.53
	within		0.91	-3.52	4.56
Log (Rainfall, mm)	overall	7.7	0.41	6.13	8.6
	between		0.33	6.5	8.29
	within		0.25	6.63	8.34
ΔNER (Rp/USD, %, yoy)	overall	-5.98	5.28	-12.59	0.63
World oil price inflation (Brent, %, yoy)	overall	-3.73	22.5	-47.04	30.64
Log (World price index, 2009 =100)	overall	4.33	0.28	3.89	4.84
West provinces, n = 17					
Inflation (%, yoy)	overall	4.57	2.56	0.23	11.58
	between		0.46	3.62	5.41
	within		2.52	0.79	11.29
Output gap, total GRP (%)	overall	0.18	0.85	-2.87	2.83
	between		0.14	-0.03	0.5
	within		0.84	-2.71	2.59
Output gap, non-mining GRP (%)	overall	0.2	0.8	-2.67	2.73
	between		0.14	-0.03	0.53
	within		0.79	-2.88	2.47
East provinces, n = 17					
Inflation (%, yoy)	overall	4.69	2.45	0.27	11.91
	between		0.47	3.93	5.67
	within		2.41	0.1	10.93
Output gap, total GRP (%)	overall	0.13	2.48	-12.28	9.4
	between		0.31	-0.76	0.6
	within		2.46	-11.86	10.28
Output gap, non-mining GRP (%)	overall	0.11	1.04	-3.18	4.39
	between		0.18	-0.21	0.5
	within		1.02	-3.56	4.51

Sources: Author's computation.

the backward-looking component of projected inflation is consistently higher than 0.75. In the Indonesian context, Wimanda et al. (2011) document that backward-looking expectations are more important (around 0.72) than forward-looking expectations (about 0.22). Following Galı and Gertler (1999) and Gali et al. (2005), generalized method of moments (GMM) estimation techniques of Arellano-Bond-Bover (Arellano & Bover, 1995; Blundell & Bond, 1998, 2002) are used in this study to estimate Eq.2. The GMM is suitable for adjusting for residual autocorrelation and solving the problem of endogeneity.[6]

We use annual data from 2012 to 2019 at both provincial and national levels to estimate the Phillips curve. The province-level variables include the CPI inflation rate (π), output gap (*ygap*), and rainfall (*rain*). The CPI inflation at the province level is the percentage change of CPI over twelve months. The province-level CPI is calculated as the weighted average of the city-level CPI using the following formula:

$$CPI_{it} = \sum_{j \in N_i} w_{j2012} x CPI_{jt} \tag{3}$$

where CPI_{it} is the CPI of province i at time t, CPI_{jt} is the CPI of city j at time t, N is a set of indices for the city located in province i, w_{j2012} is the consumption weight of city j based on the 2012 cost of living survey ("Survei Biaya Hidup").[7] The output gap is calculated as the log difference between the real GRP and its trend component filtered using the Hodrick-Prescott (HP) technique. We multiply it by 100 to get the output gap expressed as a percentage. Positive values in the final output gap values indicate that the economy is in high-

[6] It is also necessary to mention the drawback of GMM estimation methods stemming from the choice of instrument variables and the poor sampling properties, as pointed out by Binyamini (2007).

[7] It is crucial to emphasize that the inflation figures are inherently approximate and only refer to price dynamics in the capital and major cities of the province.

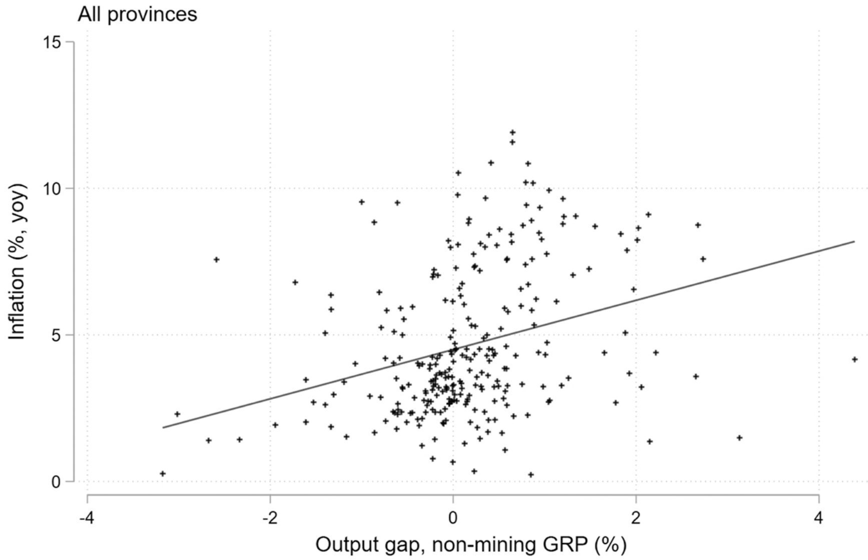

Fig. 2. CPI inflation and non-mining GRP. Note: The scatter plot shows the relationship between annual CPI inflation and non-mining output gap in 34 provinces, 2012–2019.
Source: Author's calculations.

demand condition, causing industries and workers to run well beyond their most optimal capacity. A negative output gap, on the other hand, denotes low demand that leads to excess capacity or slack in the economy.[8] There are two measures of GRP series used in this study; total GRP and GRP excluding mining (non-mining GRP hereafter). As has been discussed widely in regional economic studies of Indonesia, the non-mining GRP measure is widely used to better capture real economic activities at local level. The prevalence of extractive business indeed has a big impact on local economic activity statistics but has a much smaller impact on local social welfare. The disparity between total GRP and non-mining GRP is because major revenues from extractive operations go to non-provincial organizations, primarily the central government and foreign and domestically controlled mining firms (Hill et al., 2008). Thus, the exclusion of the mining sector in the GRP series is expected to better reflect the provincial demand condition that affects price dynamics. We are also aware that the role of the mining sector would be more significant in eastern provinces than those in the west. As shown in the fifth column of Table 1, two provinces in the east (East Kalimantan and Papua) would lose about 50% of their GRP if non-mining sector is excluded.

The national-level data is also used to reflect nationwide macroeconomic conditions. We compute the log-difference of nominal exchange rate (ΔNER) to measure the exchange rate pass-through on domestic inflation. Finally, the international crude oil price inflation (π^{oil}) and world consumer price (P^{W}) are used to capture the influence of major global commodity price changes and the extent of external supply shocks. We collect data from publicly available sources, namely, the Indonesian Central Bureau of Statistics (for π, GRP, and *rain*), Bank Indonesia (for *NER*), and Federal Reserve Bank of St. Louis (for $\pi^{oil}$and P^{W}).

Table 2 reports the summary statistics for all variables. A few points are worth noting. First, both variation between and within is non-zero, implying the presence of time-series and cross-section heterogeneity. Additionally, the time-series variation of most variables is larger than the cross-section variation across provinces. This suggests the importance of applying the unit root test to all variables to ensure stationarity. The results of various panel unit root tests show that the variables employed in the study are stationary, as shown in Table A.1 Appendix. Second, the average output gap is positive, implying that the entire economy operates above its potential level during the study period, thus putting pressure on aggregate prices to rise. Third, the variance in output gap projected using total GRP is significantly higher than the variation predicted using non-mining GRP, implying that the mining sector will exacerbate economic volatility. Fourth, eastern provinces contribute to the high variation of the output gap, both using total GRP and non-mining GRP, but the variation of the earlier far exceeds the latter. Fig. 2 shows a modest preliminary documentation of the Phillips curve in Indonesia plotted using regional data. It is possible, however, that the positive association between the output gap and inflation lacks support from suitable statistical testing. The following section will report and discuss the results based on econometric analyses.

[8] We compute output gap using GRP data beginning in 2010 because we are aware of the HP filter's sensitivity to the endpoints of the sample and aspired to create more suitable output gap series that reflect business cycle features. However, caution must be applied because the HP filter has issues with short-sample periods. In order to confirm the computed output gap, additional research over a longer time frame is advised.

Table 3
Static estimates of Phillips curve: All provinces.

Variables	(1)	(2)	(3)	(4)
	Tot GRP	Tot GRP	NM GRP	NM GRP
Output gap, total GRP_{t-1},	0.054	0.064		
	(0.184)	(0.071)		
ΔNER_{t-1}		-0.572***		-0.563***
		(0.051)		(0.048)
World oil price inflation		0.105***		0.106***
		(0.011)		(0.011)
Log (world $prices_{t-1}$)		0.053***		0.054***
		(0.002)		(0.002)
Log ($rain_{t-1}$)		0.018***		0.018***
		(0.004)		(0.004)
Output gap, non-mining GRP_{t-1},			0.258	0.401**
			(0.328)	(0.145)
Constant	4.622***	-35.595***	4.565***	-36.037***
	(0.058)	(3.306)	(0.094)	(3.461)
Observations	238	238	238	238
Number of provinces	34	34	34	34
Province FE	Yes	Yes	Yes	Yes

Notes: Model (1) and (2) use total GRP output gap, model (3) and (4) use non-mining GRP output gap. Log (world prices) and log (rain) are multiplied by 100. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Source: Author's estimates.

4. Empirical results and discussion

We begin this section by presenting results for static specification of Eq.1 reported in Table 3. We separate the results estimated using two alternatives of output gap measures: total GRP output gap (columns 1 and 2) and non-mining GRP output gap (columns 3 and 4). We first test the relationship between inflation and the output gap for each alternative. We find that the output gap coefficient is positive but not statistically significant, either using total GRP or non-mining GRP output gap. Once macro variables are included, all variables in column 4 have the expected sign and are statistically significant (at least within 5% significance level); inflation is being driven up by demand pressures, exchange rate movements, international oil price inflation, dynamics in global prices and domestic rainfall condition. The estimated parameter of interest implies that a one percentage point increase in output gap is associated with the rise in inflation by about 40 basis points. Estimates for the control variables exhibit the anticipated signs. The estimate of NER means that one percentage point increase in exchange rate of Rp/USD is associated with rising inflation by 56 basis points.[9] The coefficient of world oil price inflation implies that a one percentage point increase in oil price is associated with about 10 basis points surge in inflation. A percentage increase in world consumer price index in previous year could increase domestic inflation by more than 5 basis points.[10] Finally, the significant effects of rain support the widely held argument that increased rainfall volume would disrupt the harvest of a variety of food commodities, notably horticulture products. Moreover, high rains is likely to disrupt the country's food supply due to poor connection, causing the price of many basic food items to rise due to a lack of supply.

It is also important to note that non-mining GRP output gap shows a significant coefficient when macro variables are included in the model. These results imply two crucial messages for initial investigation. First, in addition to applying the region fixed effect to handle unobserved heterogeneity, incorporating variables that capture national shocks is also required to estimate the Phillips curve using sub-national data. Second, the difference between the total GRP output gap and non-mining GRP output gap is evident. As discussed earlier, this finding indicates the relevance of excluding the mining sector in output gap estimation to capture local economic activities better.

Next, we will present and discuss the results from the dynamic specification estimated using system GMM. Since we want to know which output gap measures – whether total GRP or non-mining GRP – is the best indicator of inflation, we compare the two variables. As shown in Table 4, both total GRP (Tot GRP) and non-mining GRP (NM GRP) output gaps have expected signs and are statistically significant; however, the magnitude of non-mining GRP output gap is larger than the total GRP output gap. If the total GRP output gap increases by one percentage point, roughly 4 basis points rise in inflation is expected; while inflation is predicted to rise by almost 30 basis points when non-mining GRP output gap increases by the same magnitude.[11] This suggests that the inflation rate is more

[9] This estimate is higher than the estimate of Wimanda et al. (2011) when investigating Phillips curve in Indonesia using national data, possibly owing to different period of investigation.

[10] The effects of foreign consumer prices are potentially transmitted through foreign trade. Import data from Central Bureau of Statistics show that raw materials and auxiliary items, which are assumed to be used in the domestic production process, account for 73% of total imports in Indonesia in terms of value, or 94% in terms of volume, in 2019.

[11] The point estimate of total GRP output gap is close to the lower band of point estimates in the study of Wimanda et al. (2011) that uses monthly national-level data from 1980 to 2008.

Table 4
Dynamic estimates of Phillips curve: All provinces.

Variables	(1)	(2)
	Tot GRP	NM GRP
Output gap, total GRP_{t-1}	0.042*	
	(0.022)	
$Inflation_{t-1}$	0.301***	0.285***
	(0.006)	(0.007)
ΔNER_{t-1}	-0.503***	-0.499***
	(0.009)	(0.009)
World oil price inflation	0.114***	0.114***
	(0.002)	(0.002)
Log ($world\ prices_{t-1}$)	0.049***	0.050***
	(0.001)	(0.001)
Log ($rain_{t-1}$)	0.005***	0.005***
	(0.001)	(0.001)
Output gap, non-mining GRP_{t-1}		0.292***
		(0.018)
Constant	-24.983***	-25.580***
	(0.494)	(0.425)
Sacrifice ratio[a]	16.64	2.45
Observations	238	238
Number of provinces	34	34
AR(1)-test (*p*-val)	0.00	0.00
AR(2)-test (*p*-val)	0.76	0.93
Hansen test (*p*-val)	0.16	0.16
Sargan test (*p*-val)	0.00	0.00
Number of instruments	33	33

Behera et al. (2018), the sacrifice ratio is computed as [(1-lagged inflation coeff.)/output gap coeff.], or the inverse of the long-run slope of the Phillips curve. Model (1) and (2) use total GRP and non-mining GRP output gap, respectively. Log (world prices) and log (rain) are multiplied by 100. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. For first-order and second-order serial correlation, the Arellano-Bond tests AR(1) and AR(2) are used. The Sargan/Hansen tests are used to ensure that the GMM estimators are not overidentified. Source: Author's estimates.

responsive to non-extractive economic activities, at least at the local level. The implied sacrifice ratio – the potential loss in output to compensate for reducing inflation by one percentage point – is in the range of 2.45–16.64.[12]

The coefficient of lagged inflation is also statistically significant – about 0.3 – , indicating inflation persistence or backward-looking expectation. The significant inflation persistence in Indonesia has been also documented in studies using national data in with different sampling periods (see, e.g., Wimanda et al., 2011; Juhro, 2015). The exchange rate pass-through coefficient is roughly about 0.5, similar to the results from static specifications. Similarly, the estimated impact of global oil price inflation and worldwide prices is comparable to that of static models. The effects of rainfall condition remain significant but with a relatively smaller magnitude. Regarding the model fitness, postestimation diagnostic tests produce a satisfactory outcome: the null of no autocorrelation in first differenced errors is rejected at 1% significance level. The Sargan-Hansen test for over-identification restrictions is also rejected.[13]

This sub-section will concentrate on estimating the Phillips curve for the western and eastern provinces individually, owing to the well-documented difference in development and economic structures between the two regions. We report the results for the west and east provinces in Tables 5 and 6, respectively. However, since the sample size shrinks by half with each region, we refer to the results of this extended analysis as preliminary.

The total GRP output gap coefficient has a positive and statistically significant effect on inflation only in western provinces. Meanwhile, non-mining GRP output gap shows an expected sign and is significant both in the west and eastern provinces. This comparison implies one crucial contribution of our study on the relevance to exclude mining-sector in estimating the Phillips curve using regional data in Indonesia; when analyzing the Phillips curve relationship in the east, the non-mining GRP output gap is suggested. This premise is also supported by the statistics of regional economic structures reported in Table 1, where the share of mining industries is much higher in the eastern regions. For the west, both total GRP and non-mining GRP output gap are relevant. Nevertheless, for equal comparison, it is more suitable to contrast the west and the east using the identical output gap measure.

It is also interesting to note that the effect of output gap – either total GRP or non-mining GRP – on inflation is higher in the west vis-à-vis in the east regions. The magnitude of non-mining GRP output gap coefficient for the west is much higher than in the east (0.67

[12] Although these ratios are higher than those estimated in the case of Indian states (Behera et al., 2018), they are not too much different from the sacrifice ratios shown in other studies (see, e.g., Dholakia and Virinchi, 2017; Senda and Smith, 2008; Cecchetti and Rich, 2001).

[13] The joint null hypothesis of Sargan-Hansen test is that the over-identifying restrictions are valid, i.e., the instruments are not correlated with the error term.

Table 5
Dynamic estimates of Phillips curve: West provinces.

Variables	(1)	(2)	(3)	(4)
	Tot GRP	Tot GRP-col	NM GRP	NM GRP-col
Output gap, total GRP_{t-1}	0.462***	0.442***		
	(0.086)	(0.116)		
$Inflation_{t-1}$	0.174***	0.185***	0.152***	0.163***
	(0.023)	(0.024)	(0.022)	(0.025)
ΔNER_{t-1}	-0.606***	-0.611***	-0.577***	-0.595***
	(0.042)	(0.046)	(0.050)	(0.048)
World oil price inflation	0.133***	0.134***	0.128***	0.132***
	(0.008)	(0.009)	(0.010)	(0.010)
Log (world $prices_{t-1}$)	0.047***	0.048***	0.048***	0.048***
	(0.003)	(0.003)	(0.003)	(0.003)
Log ($rain_{t-1}$)	0.006**	0.006**	0.006**	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)
Output gap, non-mining GRP_{t-1}			0.673***	0.614***
			(0.143)	(0.156)
Constant	-25.161***	-25.443***	-24.885***	-25.351***
	(2.760)	(2.558)	(2.479)	(2.403)
Sacrifice ratio	1.79	1.84	1.26	1.36
Observations	119	119	119	119
Number of ID	17	17	17	17
AR(1)-test (p-val)	0.00	0.00	0.00	0.00
AR(2)-test (p-val)	0.66	0.66	0.53	0.62
Hansen test (p-val)	0.92	0.01	0.93	0.016
Sargan test (p-val)	0.00	0.00	0.00	0.00
Number of instruments	33	13	33	13

Notes: Model (1) and (2) use total GRP output gap, while model (3) and (4) use non-mining GRP output gap. The instrument matrix of GMM is collapsed in model (2) and (4). Log (world prices) and log (rain) are multiplied by 100. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. For first-order and second-order serial correlation, the Arellano-Bond tests AR(1) and AR(2) are used. The Sargan/Hansen tests are used to ensure that the GMM estimators are not overidentified. Source: Author's estimates.

Table 6
Dynamic estimates of Phillips curve: East provinces.

Variables	(1)	(2)	(3)	(4)
	Tot GRP	Tot GRP-col	NM GRP	NM GRP-col
Output gap, total GRP_{t-1}	0.036	0.016		
	(0.043)	(0.053)		
$Inflation_{t-1}$	0.466***	0.515***	0.447***	0.509***
	(0.064)	(0.061)	(0.080)	(0.065)
ΔNER_{t-1}	-0.263***	-0.317***	-0.349***	-0.334***
	(0.074)	(0.075)	(0.043)	(0.075)
World oil price inflation	0.073***	0.089***	0.093***	0.093***
	(0.016)	(0.017)	(0.006)	(0.017)
Log (world $prices_{t-1}$)	0.046***	0.046***	0.049***	0.048***
	(0.002)	(0.002)	(0.002)	(0.003)
Log ($rain_{t-1}$)	0.004*	0.004**	0.004**	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
Output gap, non-mining GRP_{t-1}			0.199***	0.223**
			(0.064)	(0.093)
Constant	-22.613***	-22.483***	-24.234***	-23.876***
	(2.081)	(1.268)	(2.106)	(1.662)
Sacrifice ratio	14.83	30.31	2.78	2.2
Observations	119	119	119	119
Number of ID	17	17	17	17
AR(1)-test (p-val)	0.00	0.00	0.00	0.00
AR(2)-test (p-val)	0.36	0.18	0.17	0.15
Hansen test (p-val)	0.96	0.012	0.91	0.012
Sargan test (p-val)	0.00	0.00	0.00	0.00
Number of instruments	33	13	33	13

Notes: See Notes Table 5.

vis-à-vis 0.20 - both coefficients are statistically significant). In other words, inflation in the west is more sensitive to the dynamics of local economic activity than inflation in the east. This particular finding is to some extent similar to the instability of the Phillips curve across Chinese provinces (Mehrotra et al., 2007).

Table A.1
Unit root test results.

Variable	(1) LLC	(2) Breitung	(3) Hadri
Inflation (%, yoy)	0.00	0.00	0.80
Output gap, total GRP (%)	0.00	0.00	0.08
Non-mining GRP output gap (%)	0.00	0.00	0.00
Log (Rainfall, mm))	0.00	0.00	0.88
ΔNER (Rp/USD, %, yoy)	0.00	0.00	0.00
World oil price inflation (Brent, %, yoy)	0.00	0.00	0.64
Log (World price index, 2009 =100)	0.00	0.06	0.00
Log (Import price index, 2010 =100)	0.00	0.06	0.00

Notes: The table reports *p*-values for the null hypothesis. For LLC (Levin-LinChu) and Breitung tests, the null hypothesis states that panels have unit roots rather than being stationary. The null hypothesis for the Hadri test is that all panels are stationary against some panels have unit roots. The sampling period runs from 2012 to 2019. Source: Author's estimates.

The coefficients of lagged inflation also mark west-east segregation. The presence of inflation persistence is stronger in the east, with point estimate around 0.45; while for the west, the figure is around 0.15. These suggest that the prices in the east are more rigid, while the prices in the western provinces are more flexible. This different behavior in regional inflation-output relationship has crucial implications for implementing uniform monetary policy in a structurally diversified territory (Durand et al., 2008). Although monetary policy targets macro variables at the national level, understanding its interaction with regional real economic activities is also policy-relevant. For example, the implied sacrifice ratio for the west is 1.26 in the case of non-mining GRP output gap, much lower than that in the east for the same measure of output gap, 2.78.[14] A real implication for the conduct of monetary policy may be drawn from this: excess demand conditions in the west may have a bigger impact on inflation, and any disinflation monetary policies may entail a lower sacrifice in output. In other words, reducing inflation by 1% is more costly in the east than in the west. Thus, government needs to further develop supply-side strategies when addressing rising inflation pressure in the east. Put differently, if different features between regions are not taken into consideration, the stance of monetary policy to anticipate inflation may overburden economic activity in the western provinces. This argument is in line with earlier study which concludes that monetary policy impacts on regional inflation in Indonesia largely depend on regional economic characteristics (Aginta & Someya, 2022).

We also see the possibly suspect numerous instruments in each model with standard GMM, despite only employing one lag for instruments. To address this issue, we implement collapsing strategy (Roodman, 2009). Model (2) and (4) in Tables 5 and 6 exploit the collapsed instrument matrix. Broadly speaking, the estimates based on collapsed instruments do not deviate from the results of standard GMM. Instead, their magnitude is fairly comparable and statistically significant, with much smaller number of instruments.

Another intriguing finding is the difference in the effects of exchange rate dynamics on inflation in the west and the east. The exchange rate pass-through appears to be more prevalent in the western provinces, with a size around 0.6, slightly higher than the point estimates using all provinces presented in Table 4. While in the east, the magnitude of exchange rate pass-through is nearly a half of that in the west. One preliminary argument to support these findings is the degree of import share to local production; western provinces have a higher import share than their eastern counterparts, on average (Table 1). This role of trade openness on exchange rate pass-through has been extensively examined in previous empirical studies (Ca'Zorzi et al., 2007; Eser et al., 2020; Phuc & Duc, 2021). Another possible factor might come from the difference in the fraction of flexible-price firms in the two regions. Subject to data availability, further research could explore this possibility. Finally, the effects of international oil price inflation also differ in the west and the east, potentially due to different weight of transportation costs item in the CPI basket of provinces in the two regions. Nevertheless, evaluation on the basis of these west-east differences in the Phillips curve relationship is beyond the scope of this paper. Yet, it is worth pointing out that our findings unmask hidden regional differences that might be useful in designing monetary policy actions by the central bank.

4.1. Robustness test

We then test the robustness of the results by using alternative variables. First, we replace global consumer price index with a wholesale price index for imported commodities and imported raw materials, capturing the extent of transmission from external to domestic price dynamics. Second, we alter international oil price inflation with dummy variable to capture domestic fuel price hike in November 2014 and October 2018 following government policies to reduce the burdensome fuel subsidies. The results are presented in Table A.2 Appendix, which also includes the results of the collapsed instrument matrix.[15]

The qualitative results across all models are considerably unchanged: the Phillips curve coefficients remain statistically significant with the expected sign. The comparison of output gap coefficients supports the findings from our baseline – the impact of the non-mining GRP output gap is larger, and the slope of the Phillips curve is steeper in the west than the east. Lastly, the alternative

[14] These ratios are approximations. It is important to bear in mind the possible biases in these results. Further studies with more focus on estimating the sacrifice ratio are therefore suggested.

[15] The definition of the alternative variables is provided in the notes of Table A.2.

Table A.2
Robustness test results.

Variables	All provinces				West provinces				East provinces			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Tot GRP	Tot GRP-col	NM GRP	NM GRP-col	Tot GRP	Tot GRP-col	NM GRP	NM GRP-col	Tot GRP	Tot GRP-col	NM GRP	NM GRP-col
Output gap, total GRP_{t-1}	0.055***	0.088*			0.499***	0.510***			0.075	0.025		
	(0.013)	(0.047)			(0.092)	(0.099)			(0.049)	(0.027)		
$Inflation_{t-1}$	0.244***	0.283***	0.232***	0.262***	0.129***	0.121***	0.100***	0.105***	0.507***	0.452***	0.523***	0.448***
	(0.006)	(0.034)	(0.005)	(0.038)	(0.012)	(0.015)	(0.020)	(0.020)	(0.101)	(0.078)	(0.123)	(0.082)
ΔNER_{t-1}	-0.159***	-0.145***	-0.153***	-0.143***	-0.169***	-0.172***	-0.169***	-0.166***	-0.055	-0.074**	-0.045	-0.075**
	(0.004)	(0.016)	(0.003)	(0.016)	(0.011)	(0.013)	(0.012)	(0.014)	(0.043)	(0.033)	(0.052)	(0.035)
Log (P^M)	0.115***	0.114***	0.116***	0.115***	0.118***	0.119***	0.121***	0.121***	0.104***	0.103***	0.103***	0.104***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Fuel	1.979***	1.844***	2.013***	1.883***	1.795***	1.839***	1.877***	1.854***	1.828***	1.933***	1.780***	1.982***
	(0.015)	(0.138)	(0.021)	(0.147)	(0.118)	(0.076)	(0.075)	(0.082)	(0.233)	(0.229)	(0.339)	(0.242)
Log ($rain_{t-1}$)	0.007***	0.006***	0.007***	0.007***	0.010***	0.011***	0.010***	0.010***	0.004**	0.005***	0.005**	0.005***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Output gap, non-mining GRP_{t-1}			0.278***	0.304***			0.686***	0.681***			0.142**	0.159**
			(0.022)	(0.064)			(0.171)	(0.136)			(0.062)	(0.067)
Constant	-61.029***	-60.019***	-61.739***	-61.018***	-64.131***	-65.192***	-65.402***	-65.700***	-53.904***	-53.750***	-54.403***	-54.998***
	(0.765)	(2.055)	(0.428)	(2.099)	(1.761)	(2.784)	(2.429)	(2.692)	(1.432)	(1.367)	(1.782)	(1.573)
Sacrifice ratio	13.75	8.15	2.76	2.43	1.75	1.72	1.31	1.31	6.57	21.92	3.36	3.47
Observations	238	238	238	238	119	119	119	119	119	119	119	119
Number of ID	34	34	34	34	17	17	17	17	17	17	17	17
AR(1)-test (p-val)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)-test (p-val)	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.71	0.85	0.83	0.90
Hansen test (p-val)	0.25	0.00	0.24	0.00	0.97	0.06	0.97	0.06	0.99	0.07	0.99	0.063
Sargan test (p-val)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of instruments	36	16	36	16	36	16	36	16	36	16	36	16

Notes: Model (1), (2), (5), (6), (9), (10) use total GRP output gap, while model (3), (4), (7), (8), (11), (12) use non-mining GRP output gap. The instrument matrix of GMM is collapsed in models with even number. Log (P^M) is the log of wholesale price index for imported commodities and imported raw materials (2010=100), multiplied by 100.
The data is collected from Indonesian Central Bureau of Statistics. *Fuel* = 1 for year of 2014 and 2018, 0 otherwise. Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$. For first-order and second-order serial correlation, the Arellano-Bond tests AR(1) and AR(2) are used.
The Sargan/Hansen tests are used to ensure that the GMM estimators are not overidentified. Source: Author's estimates.

variables show significant coefficients along with other control variables. Overall, these results confirm those of our baseline model.

5. Conclusion

The study aims to find new empirical evidence of the Phillips curve in Indonesia, an expanding economy with diverse geography. The empirical approach of this research, which analyzes regional-level data in a panel setting, helps to better comprehend the Phillips curve for Indonesia and adds to the robustness of prior estimates based on national data.

The findings suggest the presence of the Phillips curve relationship in Indonesia, corroborating the conclusions of the previous works. The slope of the Phillips curve estimated using regional data is found to be larger than that documented in previous studies using national-level data. In addition to the explanation of different sampling period, this larger estimate may also relate to the argument in favor of using regional data for Phillips curve estimation in inflation-targeting economies because the use of on-target national inflation rate can potentially lead to weak, or even disappearing, inflation-output link. Along with backward-looking inflation expectations, the movements of the exchange rate, international oil price inflation, and dynamics in global consumer price also have significant effects on inflation in Indonesia.

In addition, we find a larger impact of the output gap on inflation if the mining sector is excluded from output gap measurement. As has been shown in several regional economic studies, excluding mining industry from output measurement is relevant in the Indonesian context to better reflect real economic activities − and thus the economic slack for the Phillips curve − at the local level. Finally, our sub-sample analysis reveals a supplementary finding: the Phillips curve slope is steeper in the west vis-à-vis in the east, implying that disinflationary monetary policy in the east is more costly in terms of output loss. Overall, our findings reconfirm that the Phillips curve appears to remain relevant for Indonesia despite the recent global debate about the stability of inflation-output relationship.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

See in Table A.1,A.2.

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