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Explaining regional inflation programmes in Indonesia: Does inflation rate converge?

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Abstract

This paper investigates the inflation convergence of 82 Indonesian cities and discusses the remarkable regional inflation programmes in Indonesia. By employing a dynamic panel regression, the paper shows that Indonesia experienced an inflation convergence from 2013 to 2018. An intriguing finding is that the cities in Java-Bali, the largest density area, experienced a slower speed of convergence than that in cities outside the Java-Bali. This paper alleges that the development of logistic transportation and the formulation of an inflation control programme, such as the Tim Pengendalian Inflasi Daerah (TPID) or Regional Inflation Controlling Team (RICT) that has just been stationed and has commenced their duties in East Indonesia, might play an essential role in the convergence. Moreover, the coordination between the central and regional governments, represented by TPID/RICT, in implementing the effective policy (i.e. prioritising development outside Java-Bali and fostering inter-region cooperation in the commodity supply chain) is effective in stabilising and reducing the inflation rate.

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1 Introduction

Inflation is a complex economic issue that has remained the main concern in the world for governments, policy makers, central bankers, as well as macroeconomists (Hussain and Malik 2011). Inflation also associates with various circumstances ranging from the national scale (such as economic stability) to the individual scale (such as social welfare). On the national or regional scale, inflation might pertain the price surge on the general price of goods and services in a country, so it makes the economy unstable. This price surge will impact people's purchasing power, so that social welfare might be diminished.

The large population of a country makes inflation more complicated to be tackled as in Indonesia, for instance. For a population that is more than 250 million (according to the 2010 Census) scattered in 35 provinces in 2019, there will be substantial distinguished traits of inflation experienced by each region. Each region can experience different production or distribution disruptions, so that the solution of these issues should be particularly uniquely distinguished. Furthermore, the cause of inflation also does not merely consist one aspect, for instance the inflation determinant that is not only from the demand side controlled by Indonesia's central bank, Bank Indonesia, but also from the supply side such as production and distribution generally controlled by government regulation. Therefore, the precise policy is necessarily able to embrace aforementioned issues of inflation.

One policy to monitor inflation, especially at the regional level, is through the formation of a Regional Inflation Controlling Team (RICT) known as *Tim Pengendalian Inflasi Daerah* (TPID). TPID/RICT was initiated in 2008 after forming the Inflation Controlling Team known as TPI in 2005.[1] As stated in the 2017 President's Decree of the Republic of Indonesia Number 23, regarding the National Inflation Controlling Team, TPID has the following duties: collecting the price data of essential goods and services, arranging a regional policy to control inflation by referring to the national inflation policy, strengthening the logistic system and other programmes that are able to lower inflation. To run its programme, the TPID was coordinated by the local government leaders at the city or regency level. By involving local government leaders, it is expected that the TPID will be able to exercise an effective measure in controlling inflation.

The inflation target as an indicator of the inflation rate plays an important role in this disparity reduction. As Arimurto and Trisnanto (2011) argue, this policy instrument works best with a more holistic monetary policy that deals with interest rates and is anticipative in nature. This means that regions ought to be able to achieve a predetermined target of inflation rate, so that they could maintain their economic stability. Another implication of the inflation target level is the aim to overcome structural problems in the supply chain, both for goods and services that cause disruption in inventory stability. Murwito et al. (2013) suggested that regions could cooperate with each other to maintain the logistic distribution

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[1] The Inflation Controlling Team (TPI) was only one division and was centralised in Jakarta, Indonesia's capital city.

among regions in case of maintaining price stability. This is because the World Bank (2016) states that Indonesian logistics tends to fluctuate due to uncertainty in the logistics chain and the different costs of the distribution of goods and services among regions. Moreover, Susanty and Ribka (2016) noted that the high cost of distribution among islands in Indonesia enormously contributes to the lack of local product competitiveness. Consequently, Indonesia's logistic cost is approximately 26% of its Gross Domestic Product (GDP), double those of Malaysia and Singapore. Therefore, logistics problems will further increase the inter-regional inflation gaps if performance evaluation and policy making among regions are not aligned by each local government.

Systematic economic evaluation is essential to ensure that the inflation rate in each region is convergent on the inflation target. Magkonis and Sharma (2019) stated that since the 1990s, there has been an increasing number of central banks that have adopted the inflation target level, so that this target could anchor people's expectations. Adiwilaga and Tirtosuharto (2013) contended that determining a target for the inflation rate can discourage the inflation gap among regions and thus control inflation in each region. Regions would have target levels by stipulating various regional programmes that can minimise the impact of a macroeconomic shock. Studies have shown that there are various approaches to detect dispersion of the inflation rate: research on the inflation dynamic within the distribution dynamic approach (Cavallero 2011; Soares and Aguiar-Conraria, 2014), the influence of macro policies on inflation convergence (Arestis et al. 2014; Hasriati 2016; Lopez and Papell 2012), and measuring inflation convergence as an evaluation of stipulated programmes (Dridi and Nguyen 2018). These studies were able to evaluate the inflation rate in a country effectively by testing inflation convergence.

This study examines the inflation convergence in Indonesia in order to provide evidence as the basis for an Indonesian regional policy making. The convergence test results could become a main indicator to evaluate the performance of various programmes that have been undertaken thus far. As far as we aware, study of Adiwilaga and Tirtosuharto (2013) is the only study of Indonesia's inflation convergence in 26 provinces. In this study, we employed 82 cities, so we could state that our study is the first paper to test the convergence of inflation rate in the city level. We selected the city level because the city level is more well-represented and specific on inflation issues in each city, instead of provincial level that might remain too extensive to discuss. This study contributes to the literature by deploying data of regional inflation in Indonesia. The case of the Indonesian inflation is distinct due to its geographical condition as an archipelago country. The consequence of this condition is the possible high disparity of inflation rates at the regional level. This disparity takes place even if the stability of the national inflation rates has been maintained. For example, in 2009, even though the inflation rate had successfully decreased to 2.41% (year-on-year), there were 39 out of 66 cities that experienced an inflation rate greater than the national inflation, notably the greatest rate was 7.52%. The inflation variation among regions will serve as an appropriate evidence to investigate the existence of convergence. The utilisation of Indonesian regional inflation in this study becomes more advantageous due to the existence of the Regional Inflation Controlling Team in each city during the period of interest.

2 Literature review

2.1 Indonesia's archipelago and inflation

Indonesia is a huge country with a massive regional diversity. There are more than 17,000 islands within five main islands namely Sumatera, Java, Kalimantan, Sulawesi and Papua. However, those five largest islands show the remarkably distinguished density. According to the 2010 Census in Indonesia, the inhabitants of Java Islands form approximately 57.48% of the Indonesian population. Meanwhile, other larger islands such as Sulawesi, Kalimantan and Papua are inhabited by < 10% of the population, even though these three islands, along with Sumatera, cover more than 75% of the total area in Indonesia.

Given that Indonesia is a large country with a great diversity, its government has inflation as one of the main issues that ought to be tackled. The literature on macroeconomics has extensively discussed the inflation control policy. For example, Samuelson and Nordhaus (2010) adopted the Philips Curve theory and postulated that reducing output and raising unemployment may temporarily discourage inflation. As for Suseno and Astiyah (2009), they advocated three major policies to be implemented to address inflation: the monetary, fiscal, and external sector. The government may stipulate fiscal and external policies to control inflation, i.e. regional inflation specific determinant. Bank Indonesia may also issue policies using several instruments, such as policy rate, market operation and minimum reserve requirement. These three policies are formulated and adjusted over period to accommodate the constant changing in inflation.

Indonesia uses Consumer Price Index (CPI) as a reference for calculating inflation. Using Survei Biaya Hidup (SBH) or the Cost of Living Survey, Badan Pusat Statistik (BPS) or the Central Statistics Bureau has been including more cities to calculate inflation. In 2002, the data collected by SBH from 45 cities were used to monitor the next 5 years of inflation. The 2007 SBH was conducted in 66 cities until 2014. Eventually, the latest SBH is 2012 SBH which covers 82 cities and has been used since 2013 to now. BPS calculates inflation depending on three approaches: *month-to-month (m-t-m), year-on-year (y-o-y), and year-to-date (y-t-d)*. The *month-to-month* approach depends on the ratio of CPI in the current month to that of the previous month in the same year. The *year-on-year* approach is based on the ratio of CPI in the current month to that of the same month of the previous year. As for the *year-to-date* approach, it depends on the ratio of CPI in the current month to the year-end month (i.e. December) of the previous year. According to these three approaches, the inflation target uses the *y-o-y* approach as the inflation target rate, such as $3.5\% \pm 1\%$, means that the inflation rate is tolerated from 2.5% to 4.5%.
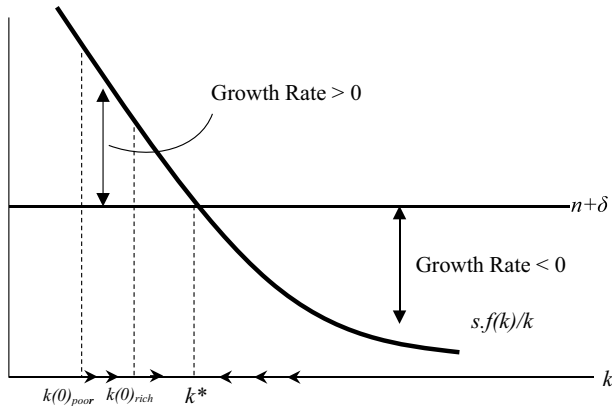
Fig. 1 Convergence theory. *Note:* k = capital. *Source*: Barro and Sala-i-Martin (2004)

2.2 Convergence and inflation convergence

Convergence was originated from the neoclassical theory about the negative relationship between per capita economic growth and the level of output or one's income, as illustrated in Fig. 1.

Figure 1 illustrates the theory of convergence initiated by Barro and Sala-i-Martin (1992). The growth rate of capital (k) is given by the vertical distance between the saving curve $s \cdot \frac{f(k)}{k}$ and the effective depreciation line ($n + \delta$). k^* is the point at which capital rate is a steady state which means the saving curve cross the effective depreciation line. If the capital level is less than the capital level at the steady state (($k < k^*$), k would positively grow and increase towards k^*. Conversely, when the rate of the capital of k is greater than k^*, k would negatively grow and converge to k^*. Barro and Sala-i-Martin (1992) emphasised that the growth of the capital of poor countries apparently showed larger than the capital of rich countries. This condition occurred due to the rapid development in poor countries, such as the establishment of infrastructures and facilities, which then raised their capital intensity level. Meanwhile, in rich countries, all this development has been accomplished several years before poor countries even begin.

Barro and Sala-i-Martin (1992) developed the concept of Sigma convergence (σ), which means a movement towards a point, so that disparity among regions decreases to some degree. Sala-i-Martin (1996) shows that in the presence of the σ-convergence, the value of the steady state in a cross-sectional dispersion would finally be obtained and would diminish the probability of opposite claims on the central monetary authority. The convergence notion postulated by Barro and Sala-i-Martin (1992) was then redefined by Kocenda and Papell (1997) in inflation case. Kocenda and Papell (1997) proposed that it is a condition when inflation disparity decreases or when the differential among countries increases over time. Inflation convergence occurs if there is no significant change in the inflation rate among regions in a country. Changing the inflation rate over time is normal, but this change normally does not exceed the average national inflation. Inflation convergence is, therefore, a condition where the rate of each

province converges on the equilibrium line of the average national inflation (Hasriati 2016).

2.3 Existing literatures

Approaches to testing convergence are varied, ranging from measuring a single country within provinces or cities as cross section, to a group of countries with another group of countries. Cavallero (2011) investigated the convergence process of the Euro Area inflation rate by employing the distribution dynamics approach. Cavallero (2011) discovered that there was an inflation convergence for 25 years from 1979 to 2006 in the Euro Area although the convergence level was not constant over time. Furthermore, the convergence process was getting stronger after introducing the Economic and Monetary Union (EMU) and the single currency in the Euro Area. Moreover, according to Cavallero (2011), the EMU has boosted trade patterns among Euro area countries and hence improved the synchronisation of inflation cycles. Lopez and Papell (2012) examined the effect of applying the Maastricht agreement on inflation convergence in European countries. The findings showed that the implementation of the Maastricht agreement prompted a high level of inflation convergence and a substantial decrease in inflation disparity. This suggests that the Maastricht range policy should be developed continuously. Adiwilaga and Tirtosuharto (2013) tested the link between inflation and decentralization by testing β-convergence and σ-convergence of 26 provinces in Indonesia from 2003 to 2008 and 2008–2012. This study suggested that decentralization significantly have impact on regional inflation in Indonesia. Holmes et al. (2014) researched income convergence in the USA by highlighting the pairwise economic procedure. This procedure allows the discovery of convergence across all observation even if co-integration could not be detected in each pair. Holmes et al. (2014) found a strong likelihood of convergence between two states with the same initial per capita incomes and geographically nearby among others. Dridi & Nguyen (2018) investigated the inflation convergence of East African countries as those countries aspired to establish the monetary union under the East African Community (EAC) in 2024. By employing the Global Vector Autoregressive (GVAR), Dridi and Nguyen (2018) discovered that the inflation rates of EAC countries are not persistent. This result indicates that the convergent inflation occurred and there was a unitary impact when the shock would affect EAC countries. The test of convergence is essential for examining the feasibility of a monetary union because if divergence exists on the inflation rate, a single monetary policy for EAC countries will be difficult. This is because in such a case, an extreme policy should be stipulated to greatly loosen the monetary policy for countries with high inflation rates and to tighten the monetary policy for countries with low inflation rates.

3 Data and methodology

3.1 Data and descriptive statistics

The CPI is the inflation measurement and data obtained from the BPS (Central Bureau of Statistics) is the secondary data. The inflation data are processed each month from the CPI data by calculating the *Natural Logarithm* ratio of the current month's CPI to that of the same month of the previous year (see Eq. 1). This calculation is called a *year-on-year* inflation data. Inflation is measured by adopting model as follows:

$$\pi_t = \ln\left(\frac{CPI_t}{CPI_{t-12}}\right) \times 100 \tag{1}$$

π is the inflation rate, CPI_t is the Consumer Price Index in the current month, and CPI_{t-12} is the Consumer Price Index in the same month of the previous year (for example, 2013:1 and 2012:1). The inflation measurement is calculated from the changes in the CPI percentage.

The monthly panel data based on the *year-on-year* methods consist of 82 cities, which refers to the number of the TPID in Indonesia between 2013:12 and 2018:12. This specific period was chosen because since 2013, the results of SBH (the living cost survey) showed improvement in terms of the surveyed number. Taking the density level into consideration, the 82 cities are divided into 2 regions: Java-Bali and Outside Java-Bali (see Appendix 3 for the clear division). This study includes Bali in the Java region as the similar priority development for both regions. Moreover, the study includes additional data to be analysed such as the interest rate (Bank Indonesia (BI) 7 Days Repo Rate known as BI-7DRR) (suggested by Hasriati 2016) and the money supply (M2) (suggested by Subekti 2011). As Bank Indonesia considers the change of the interest rate monthly, this variable is suitable with the monthly data of the inflation rate. As suggested by Subekti (2011), the data on the money supply at the province level are limited; thus, the money supply can use the M2 at the national level as a proxy and M2 will be subtracted from price index in each city (Hasriati 2016).

During the period December 2014 (12:2014) to December 2018 (12:2018), the inflation rate of 82 cities in Indonesia generally showed the negative trend. The average level of 82 cities in 12:2014 at 8.02% was pressed down to be 3.03% in 12:2018. The largest drop was shown in 12:2015 for about 1.33%. In this period, city of Pare–Pare of Sulawesi experienced the largest decreasing by 2.95%. Moreover, the standard deviation of inflation from 12:2014 to 12:2018 generally fluctuated, although the magnitude had been climbed down since the initial period (12:2014) by which 1.42% to the end period (12:2018) by which 1.05%. Meanwhile, in terms of regional comparison, during the period 12:2014–12:2018, the region of Java-Bali showed averagely a lower rate of inflation by which 3.98% than that of the region outside Java-Bali at 4.30%. This magnitude showed identical circumstance with the average standard deviation of Java-Bali region experiencing 0.45 point smaller than region of outside Java-Bali.

Interest rate and money supply (M2) showed the opposite trend. The interest rate that is associated by BI-7 Days Repo Rate generally showed the negative trend. There are several periods in which Bank Indonesia did not accustom the interest rate, respectively; the longest period was 11 months that occurred during the period 3:2015–12:2015 with interest rate at 7.5%. This level was then evaluated in the following month, and it was 7.25%. The highest interest rate was 7.75%, and this was in 2014:12 and 2016:1. This magnitude is understandable since the rate of the national inflation during the same period showed the highest level (8.02%) among other periods. National money supply (M2) showed an increasing trend in level as well as in growth from 12:2012 to 12:2018. The increasing money supply showed the largest amount in 12:2016 at which 136,325 billion which was a 2.8% growth compared to the previous month

3.2 Methodology

This study employs the dynamic panel data regression to detect the sigma (σ) convergence. The dynamic panel data regression allows the inclusion of the lag variable as regressors. However, it may generate an endogeneity issue when employing the Fixed Effect Model (FEM) (Seo and Shin 2016; Ullah et al. 2018). Hence, the Generalised Method of Moments is used. The dynamic panel data model is specified below.

$$y_{it} = \delta y_{i,t-1} + x'_{it}\beta + u_{it} \tag{2}$$

where δ is a scalar, x_{it} is $1xK$ matrix and β is $Kx1$ matrix. u_{it} is an error component containing $\mu_i + v_{it}$ where μ_i is individual effect assumed independent and identically distributed (IID) $(0, \sigma_\mu^2)$; v_{it} is an independent error term or a transient error. The static panel data model would substantially exhibit efficiency and consistency in treating μ_i, yet the dynamic panel data would not totally tolerate as $y_{it} = f(\mu_i)$ and so as $y_{i,t-1}$. Therefore, a high correlation occurs (Baltagi 2005).

The Generalised Method of Moments consists of two estimating procedures: First-Difference GMM (Diff-GMM) and System GMM (Sys-GMM). Arellano and Bond (1991) suggested a difference-GMM (diff-GMM) approach to overcome the endogeneity problem by applying the econometric model to the first difference transformation, and all lagged variables are employed as the instrument variable. For instance, the autoregressive dynamic panel data model (AR1) without exogenous regressors could be specified to explore this notion (Eq. 3).

$$y_{it} = \delta y_{i,t-1} + \mu_i + v_{it} \tag{3}$$

where $\delta < 1\delta$ as scalar, $E(\mu_i) = 0, E(v_{it}) = 0$, and $E(\mu_i v_{it}) = 0$ for all $i = 1, 2, \dots n$, $t = 1, 2, \dots .T$. Estimating consistent δ which $N \to \infty$ in certain t, so that first difference equation is specified below.

$$y_{it} - y_{it-1} = \delta(y_{i,t-1} - y_{i,t-2}) + (v_{it} - v_{i,t-1}) \tag{4}$$

This transformation would eradicate an individual effect captured by μ_i, so that $Corr\left(y_{it}, y_{i,t-1} - y_{i,t-1}\right) \neq 0$ and $Corr\left(y_{it}, v_{it} - v_{i,t-1}\right) = 0$. y_{i1} as a valid instrument is resulted for $t = 3$; y_{i1} and y_{i2} are valid for $t = 4$. Hence, valid instrument variables in T-period are $(y_{i1}, y_{i2}, \ldots y_{i,t-2})$. Nevertheless, Koçak (2017) contended that when the independent variables are persistent over time, the lagged level of variables could be too weak instruments for the first difference, so that diff-GMM causes biased and inconsistent estimators. Hence, Arellano and Bover (1995) and Blundell and Bond (1998) postulated the Sys-GMM approach to eradicate the inconsistent likelihood and biased in the diff-GMM, thereby making so that the estimators become more efficient. Moreover, Arellano and Bover (1995) proposed the system estimation to decrease biases and comparative inaccuracy related to difference estimation (Aiyegbusi and Akinlo 2016).

Blundell and Bond (1998) suggested to employing the initial condition to improve the properties of the standard diff-GMM estimator when the time (t) period is small. Sys-GMM combines the first different model and level model with the matrix displayed below.

$$Z* = \begin{bmatrix} Z_i & 0 & 0 & \cdots & 0 \\ 0 & \Delta y_{i2} & 0 & \cdots & 0 \\ 0 & 0 & \Delta y_{i3} & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \ddots & \vdots \\ 0 & 0 & 0 & \cdots & \Delta y_{i,t-1} \end{bmatrix}$$

where Z_i^* is defined as instrument variable matrix. The second-degree moment conditions are stated as $E\left(Z_i^{*\prime} u_i^*\right) = 0$.

The Generalised Method of Moments (GMM) requires three specification post-tests to validate the model instruments (Gnangnon 2019). The first and second tests are, in their respective order, the first-order differentiated correlation in the error term (AR1) and the second-order autocorrelation (AR2). The alternative hypothesis (H_0) would be rejected (autocorrelation is absent) if the p_{value} for the test is greater than 10% of the significant level. Meanwhile, the third test is the Sargan Test of over-identifying restrictions that decides the validity of the employed instruments in the estimator. The Sargan Test uses the chi-square value χ^2: if the Chi-square value's probability is less than its significance rate at 10%, the model instrument is not valid.

In this study testing the σ-convergence is preferred as it would indicate the reduction of disparities among regions over the years (Wild 2015) to the β-convergence that would detect the catching-up or lagging-behind effect of regions. As this study employs panel analysis, it tests the unit root by Levin et al. (2002) for the data of inflation, interest, and money supply to validate the use of variables. The hypothesis for this test is H0, and it is rejected when there is no unit root on the variable. To avoid bias on the GMM approach, we included the interest rate (in percentage) and money supply (in percentage) calculated from the amount of Ln M2 of the national money supply subtracted from the price index of each city (see Hasriati, 2016) as the controlled variable. Based on Wild (2015), the equation of the σ-convergence test is as follows.

Table 1 Convergence test results

Group	Parameter		σ-Convergence
Indonesia	Constant	β_0	148.42***(7.013)
	W_{t-1}	β_1	−0.365***(0.009)
	ir_{it}	β_2	−0.066***(0.005)
	MS_{it}	β_3	−14.012***(0.791)
	Sargan test: χ^2 (1126)	80.60	
	AR (1)	0.000***	
	AR (2)	0.44	
Java-Bali	Constant	β_0	−7.169**(11.082)
	W_{t-1}	β_1	−0.314***(0.061)
	ir_{it}	β_2	−0.043**(0.022)
	MS_{it}	β_3	0.695(1.041)
	Sargan test: χ^2 (973)	24.349***	
	AR (1)	0.011**	
	AR (2)	0.995	
Outside Java-Bali	Constant	β_0	65.349***(19.232)
	W_{t-1}	β_1	−0.339***(0.022)
	ir_{it}	β_2	−0.013***(0.018)
	MS_{it}	β_3	−6.17***(1.81)
	Sargan test: χ^2 (1126)	52.46	
	AR (1)	0.000***	
	AR (2)	0.391	

***Significant at 1%; **Significant at 5%; *Significant at 10%, *AR (1)* the first-order autoregressive, *AR (2)* the second-order autoregressive, *Coeff* coefficient, Standard errors are in parentheses following coefficient. χ^2 is Chi square followed by degree of freedom (*df*)

$$\Delta W_{it} = \beta_0 + \beta_1(W_{i,t-1}) + \beta_2(ir_{i,t}) + \beta_3(MS_{i,t}) + \varepsilon_{it} \tag{5}$$

where W_{it} is the inflation value of the current period (x_{it}) subtracted by from the mean of the inflation value in each period, ΔW_{it} is the W_{it} of the current period subtracted by from the $W_{i,t-1}$. *ir* is the interest rate, and *MS* is the money supply. β represents the coefficients where β_0 is constant; β_1 is the convergent coefficient; β_2 is the coefficient for the interest rate; β_3 is the coefficient for the money supply; $\varepsilon_{i,t}$ is the error term. As Eq. (5) stated the model of convergence in which ΔW_{it} is affected by W_{it-1}, *ir*, and *MS*, so we realised that there would be endogeneity problem between W_{it-1} and *ir* as well as *MS*. Mylonidis and Oikonomou (2019) suggested that GMM could rely a set of instruments to remove endogeneity. Hence, we set interest rate (*ir*) and *MS* as the instrument variables by using GMM to solve endogeneity problem. The research hypothesis is that H_0 is rejected if β_1 is negative, which means there is σ-convergence of inflation between among cities in Indonesia.

4 Results

There are multiple tests of inflation convergence in this study: the overall 82 cities and the regional tests comprising Java-Bali and Outside Java-Bali. These tests are run using the model developed by Barro and Sala-i-Martin (1991). The result of the test is shown in Table 1.

From Table 1, it is obvious that all employed instrument variables are valid as the Sargan Test shows an insignificant level at 10%. The Autocorrelation tests at AR(1) (the first-order differentiated error) existed for Indonesia as a whole as well as for two divided groups. Meanwhile, AR(2) (the second-order differentiated error) shows the absence of autocorrelation for those three divided groups.

The convergence indicator β_1 is significant. The 82 cities converge at 36.5%. At the regional level, Java-Bali's convergence is at 31.4%, lower than the convergence rate outside Java-Bali which is at 33.9%. It is worth noting that the speed of convergence in Java-Bali, the region with the largest population, is lower than that in regions outside Java-Bali. This finding contradicts with study of Adiwilaga and Tirtosuharto (2013) that discovered the divergent of inflation rate during 2003–2012. This different finding might occur because TPID has been officially formed after 2008, so that study of Adiwilaga and Tirtosuharto (2013) had not catch the convergence moment by using period of 2003–2012. However, subsequently, Adiwilaga and Tirtosuharto (2013) also tested the convergence moment from 2008 to 2012. The result showed that inflation convergence existed even though with immensely low speed. Hence, the latter finding of Adiwilaga and Tirtosuharto (2013) supports our study that inflation convergence might exist and get quicker after TPID has been formed in 2008.

We also emphasised variables of interest rate and money supply. This study has revealed that the interest rate negatively influences inflation growth which means that when the authority (Bank Indonesia in Indonesia's case) increases the interest rate, the inflation rate will be decreased. This finding is supported by classical theory (i.e. Keynesian economics and monetary policy) and recent study (e.g. Lelo et al. (2018)). However, our study is somewhat different with Lelo et al. (2018) because this study employed time-series case in which interest rate influenced inflation rate of one section (i.e. Indonesia), while our study employed panel data in which interest rate influenced several inflation rates of some cross section (i.e. 82 cities). Since there is negative direction of interest rate in influencing inflation rate, this condition implies that the monetary instrument remains one of the effective monetary instruments in controlling inflation in Indonesia (Warjiyo, 2017).

Another point revealed by this study is an opposite finding as emphasised by classical theory that postulated the positive influence of money supply to the inflation rate. The result shows that the money supply outside Java-Bali and at the national level negatively influences the inflation rate. This finding indicates that the increasing amount of the money supply in Indonesia is not the main issue in controlling inflation (Nurjannah et al., 2017). This notion is also supported by Utami and Soebagiyo (2013) who suggested that the negative influence of the
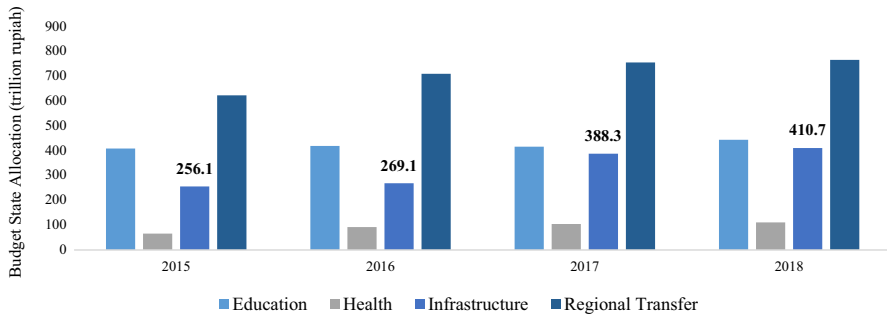
Fig. 2 Spending on state budget in 2015 to 2018. *Source*: Ministry of Finance (2019)

money supply on the inflation rate is due to the large amount of quasi-money. Money supply in the context of M2 consists of narrow money (M1), quasi-money and securities other than shares. From 2013 to 2018, quasi-money was recorded as forming more than 70% of the total money supply. However, quasi-money is characterised as a non-liquid value. Hence, although the amount is large, it does not sufficiently influence inflation in a positive direction as classical theory postulated (Utami and Soebagiyo 2013).

The main explanation of the reason behind the diminished dispersion of inflation levels among cities over the period 2013–2018, notably the larger speed of disparities reduction outside Java-Bali, could be the improvement of the logistic infrastructure. Iskandar and Subekan (2017) stated that infrastructure development was able to facilitate transportation and goods distribution in East Indonesia, especially in Papua (e.g. the construction of the Trans-Papua road). The Data of State Budget of Indonesia shows a significant growth of budget for infrastructure in 2017 at 44% (Fig. 2).

This growth is the largest growth among other allocations in the 2017 Budget State. This budget was then allocated for the development of various infrastructures such as roads, irrigation, bridges, and dikes. The Committee for Acceleration of Priority Infrastructure (CAPI) or (Komite Percepatan Penyediaan Infrastruktur Prioritas KPPIP) (2017) stated that more than 50% of the development projects are being undertaken outside Java. In addition to the development of land logistic infrastructure, there is a significant number of new ports and additional shipment routes from one port in Java to another main island. Since Indonesia is an archipelago country, the establishment of new ports might contribute significantly to setting down the inflation level by reducing the logistic cost.

Regional governments also have allocated a large amount of their budget to infrastructure. The Data of Regional Gross Domestic Product of province levels revealed that the spending for the Gross Fixed Capital Formation (GFCF) of provinces has averagely been more than 30% since 2013. Table 3 provides the data of the regional spending of provinces captured by GFCF from 2013 to 2017.

According to Table 2, the largest province spending for capital is Central Kalimantan (outside the Java-Bali Region) at 45.23%. This study shows that Central Kalimantan spent approximately 21.7% in 2017 on infrastructure only. Moreover, we pointed out the 10 largest provinces and noted that Jakarta is the only

Table 2 Spending of regions (province level) in capital sector from 2013 to 2017. *Source*: Statistic Central Bureau of Indonesia

No.	Province	Year					Average spending	Region
		2013	2014	2015	2016	2017		
1	Central Kalimantan	45.19	45.94	45.51	45.19	44.33	45.23	Outside Java-Bali
2	Central Sulawesi	39.52	44.47	43.40	43.15	41.16	42.34	Outside Java-Bali
3	Jakarta	44.20	42.94	40.87	39.24	39.18	41.29	Java-Bali
4	Bengkulu	41.37	41.98	40.27	41.10	41.08	41.16	Outside Java-Bali
5	East Nusa Tenggara	33.62	38.92	40.72	42.56	42.44	39.65	Outside Java-Bali
6	South Sumatera	41.22	40.92	37.34	38.70	38.51	39.34	Outside Java-Bali
7	South Sulawesi	36.66	36.98	37.01	37.22	37.49	37.07	Outside Java-Bali
8	West Nusa Tenggara	39.01	39.02	34.19	35.31	35.53	36.61	Outside Java-Bali
9	Aceh	32.12	33.76	35.69	37.37	37.03	35.19	Outside Java-Bali
10	West Kalimantan	34.11	34.05	34.81	34.10	33.71	34.15	Outside Java-Bali
11	North Sulawesi	34.39	32.51	34.05	34.34	34.88	34.04	Outside Java-Bali
12	Bali	33.43	31.11	31.37	32.52	32.04	32.09	Java-Bali
13	North Sumatera	31.97	31.55	31.90	31.60	31.19	31.64	Outside Java-Bali
14	Lampung	31.71	30.77	30.35	30.51	31.56	30.98	Outside Java-Bali
15	Gorontalo	31.19	31.45	31.50	30.65	29.84	30.93	Outside Java-Bali
16	Central Java	29.18	29.76	30.53	30.55	30.90	30.18	Java-Bali
17	Papua	29.58	31.16	31.13	29.48	29.51	30.17	Outside Java-Bali
18	West Sumatera	29.75	30.12	30.52	30.35	29.93	30.14	Outside Java-Bali
19	Yogyakarta	28.56	29.88	30.36	30.39	31.17	30.07	Java-Bali
20	Banten	28.45	28.95	29.19	29.62	30.59	29.36	Java-Bali
21	Riau	24.35	25.50	30.34	32.46	33.80	29.29	Outside Java-Bali
22	Maluku	28.73	28.19	28.11	29.69	30.41	29.02	Outside Java-Bali
23	East Java	27.53	27.49	27.46	27.91	28.16	27.71	Java-Bali
24	North Maluku	26.00	25.83	27.20	28.70	30.44	27.63	Outside Java-Bali
25	East Kalimantan	24.87	26.51	28.86	28.44	26.30	26.99	Outside Java-Bali
26	West Java	23.94	24.97	25.11	24.95	25.16	24.82	Java-Bali
27	Bangka Belitung	22.17	23.03	23.51	25.03	26.04	23.96	Outside Java-Bali
28	Jambi	25.34	24.14	23.07	22.86	22.32	23.54	Outside Java-Bali
29	South Kalimantan	22.72	22.84	23.48	23.57	23.24	23.17	Outside Java-Bali

We proximate infrastructure spending due to the allocation of GFCF one of which is for infrastructure. Data is displayed based on the order of average capital spending. As of 2019, Indonesia has 34 provinces, but due to limited data of PDRB of provincial level from 2013, we collected only 29 provinces

province in Java-Bali region that is in the top 10 largest of capital spending. This magnitude indicates that there is a connection between the central government spending and the regional government spending in terms of infrastructure. Thus, when the central government is keen to develop the infrastructure to discourage the inflation caused by the logistic distribution issue, the regional government also spends more on infrastructure. Therefore, the inflation rate could expectedly be well-maintained.

Regarding legal aspects, involving parties is bound by the law that regulates the inflation-related issues. The legal basis for the formation of the TPID is the Instruction of the Minister of Home Affairs No. 27/1696/SJ about the control in the affordability of goods and services at the regional level. There is also the Presidential Decree No. 23 of 2017 about TPIN which is strongly binding. This legal support is essential for the commitment to controlling inflation. Along with this law instrument, there are various programmes that can be initiated by each TPID such as inter-regional cooperation, food e-commerce and technology development. Regions will then be able to perform domestic inflation control in terms of demand and supply.

There are several programmes implemented by TPID that are possibly able to explain the reduction of inflation disparities among regions. First, the inter-regional cooperation tackles the issue of food price volatility. This programme is built upon a memorandum of understanding between producer of a region and consumer of another region. Producer would pledge to sell commodity at a certain price range even though market prices are volatile, whereas consumer regions ought to purchase at a predetermined price range. The goal of this programme is to create market security for the producers, so that middlemen would not take advantage of the situation and prices would not plummet because of the decreasing demand. As for the consumers, they will perceive certainty about the availability of goods and the stability of prices. This programme has been conducted in Jakarta, Padang and Sulawesi.

The second programme is the utilisation of information technology by creating an application platform which aims to promote agricultural products via e-commerce. According to the Secretariat of TPIP (2019), this programme was initiated by Central Java with its integrated price monitoring system application called SiHaTi. This application serves as an early warning system and virtual meeting feature to bridge between consumers and producers while performing transactions. Through the application, consumers would be able to find out the prices set by farmers as soon as the harvesting periods end. The impact of this programme, according to the Secretariat of TPIP (2019), is that inflation in Central Java plummeted to 2.73% in 2015. This level is significant compared to the prior year (2014) when inflation reached 8.22%.

The sophisticated production technology also plays an essential role in controlling inflation. A case in point is the technology that assists farmers in producing the vital agriculture commodity, i.e. rice. The Province of West Kalimantan initiated an inflation control programme that significantly decreased rice prices. The province used a technology, named Hazton, that was able to produce good quality rice in a shorter period (shorter by 15 days) and to significantly multiply the yield per hectare. Therefore, as both quantity and quality could be improved, the stability of food prices in Kalimantan could be controlled.

There are many points to be emphasised regarding the aforementioned regional programmes. For instance, the use of technology in some regions supporting production and distribution might cause the emergence of a transfer knowledge issue in the future. Old generation could purchase and operate sophisticated machines to produce good quality commodities. However, old generation also necessarily delivers insights for the young generation, so that machine will not be stalled due to the lack ability of the young generation. Another issue related to technology empowerment is the

trade-off between the use of technology and the use of labour. This issue is essential in Indonesia given its large population. On the one hand, farmers might desire to climb up production by using advanced technology (choosing the capital intensive), but apparently, in this case, the number of farming labourers would be minimised. Therefore, both central and regional governments have the important duty of solving this potential problem to keep the balance between the capital and labour usage, which will in turn stabilise the supply of commodities and maintain farmers' welfare.

5 Conclusion

This study has aimed to test inflation convergence in Indonesia and discuss inflation control programmes in the regions. We found that there was an inflation convergence in Indonesia over the period 2013–2018. The regions outside Java-Bali recorded the highest convergence movement compared to the Java-Bali region as the largest density area. We alleged this condition is caused by the formulation of an inflation control programme, such as Tim Pengendalian Inflasi Daerah (TPID) or Regional Inflation Controlling Team (RICT) that has just been stationed and has commenced their duties in East Indonesia. Moreover, the state budget for infrastructure that prioritized more than 50% of the development projects for regions outside Java might also promote inflation convergence. In addition, the spending for infrastructure of regional governments also has been allocated in a large amount. The Data of Regional Gross Domestic Product of province levels revealed that the spending for the Gross Fixed Capital Formation (GFCF) of provinces outside Java-Bali has averagely been more than 32% since 2013 or 2% higher than the average allocation of Java-Bali. This study implies on several policy implications. First, the inflation issue is not necessarily only solved by monetary policies, but also non-monetary policies that require the regional coordination. Despite the previous belief that inflation could be temporarily controlled by increasing unemployment or increasing interest rates (e.g. the Philips Curve theory), this policy is not necessarily stipulated for medium- or long-term control. The second policy implication is the development priority for regions that remain experiencing large inflation is also supposedly concerned, for instance by providing the logistic transportation system. As one of the regional issues is the geographical condition, the development of the advanced logistic transportation system can be selected to support inter-regional cooperation, so that inflation caused by region's scarcity of commodities can be solved. Thirdly, since the regional inflation would involve the structural policy, notably the improvement of logistic distribution and infrastructure support, establishing the regional company that provides essential commodities might also necessarily promote price stability. This company can play role as a logistic supply centre to ensure the commodities distribution from or to a region secured. In addition, the complex inflation issue of Indonesia is caused by regions each of which has its unique inflation determinant. For instance, a commodity might significantly contribute to inflation rate of a region, but it does not remarkably encourage inflation in other regions. Nevertheless, regional inflation policy should not only take account partially of a certain commodity that largely contributes to regional inflation, but also should comprise simultaneously to entire commodities. Moreover,

various regional programmes such as the use of technology information and production might be applied in some regions. However, the transfer of technological knowledge from one generation to another and the possible trade-off between capital and labour usage are issues to be addressed to minimise the stalled machine problem and the idle employment in the farming sector. These possible issues could be intriguing topics for the following researches to address the limitation of this study.

Appendix 1: Descriptive statistic (1)

Groups	Number of cities	Variable	Units	Mean	SD	Min	Max
Indonesia	82	Inflation	Per cent	4.196	1.86	−2.596	17.273
		Interest rate	Per cent	5.73	1.276	4.25	7.75
		Money supply	Billion rupiah	4,918,917	469,742	4,173,327	5,760,046
Java-Bali	28	Inflation	Per cent	3.98	1.547	1.137	10.848
		Interest rate	Per cent	5.73	1.276	4.25	7.75
		Money supply	Billion rupiah	4,918,917	469,742	4,173,327	5,760,046
Outside Java-Bali	54	Inflation	Per cent	4.304	1.99	−2.596	17.273
		Interest rate	Per cent	5.73	1.276	4.25	7.75
		Money supply	Billion rupiah	4,918,917	469,742	4,173,327	5,760,046

Mean arithmetic average, *SD* standard deviation, *Min* minimum amount value in observation, *Max* maximum amount in observation

Descriptive statistic (2)

(a) Inflation *year-on-year* 82 cities December-2014 to December 2015

Indicator	Dec-2014	Jan-2015	Feb-2015	Mar-2015	Apr-2015	May-2015	June-2015	Jul-2015	Aug-2015	Sep-2015	Oct-2015	Nov-2015	Dec-2015
Mean	8.02	6.78	6.15	6.14	6.46	6.73	6.84	6.73	6.51	6.27	5.80	4.65	3.31
SD	1.42	1.46	1.60	1.65	1.67	1.73	1.67	1.55	1.55	1.53	1.47	1.52	1.51
Max	12.36	11.19	12.46	15.07	16.22	17.27	16.41	13.92	13.33	12.81	9.98	8.92	8.23
Min	3.92	3.37	2.15	2.52	1.96	1.45	2.22	3.42	2.58	2.82	2.05	1.26	0.58

Indicator	Dec-2014	Jan-2015	Feb-2015	Mar-2015	Apr-2015	May-2015	June-2015	Jul-2015	Aug-2015	Sep-2015	Oct-2015	Nov-2015	Dec-2015
National inflation target	4.50	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Mean arithmetic average, *SD* standard deviation, *Min* minimum amount value in observation, *Max* maximum amount in observation, National Inflation Target is in the range ± 1% of the target

(b) Inflation *year-on-year* 82 cities January-2016 to December 2016

Indicator	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Nov-2016	Dec-2016
Mean	3.94	4.41	4.47	3.63	3.33	3.57	3.33	3.12	3.27	3.38	3.61	3.05
SD	1.32	1.21	1.21	1.01	0.97	1.10	1.07	1.18	1.21	1.40	1.39	1.28
Max	8.07	8.86	7.60	5.61	5.50	7.49	6.24	7.14	7.20	8.72	8.94	7.49
Min	− 0.52	2.35	1.92	0.64	0.47	1.63	1.16	0.80	0.83	0.78	1.38	0.35
National inflation target	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Mean arithmetic average, *SD* standard deviation, *Min* minimum amount value in observation, *Max* maximum amount in observation, National Inflation Target is in the range ± 1% of the target

(c) Inflation *year-on-year* 82 cities January-2017 to December 2017

Indicator	Jan-2017	Feb-2017	Mar-2017	Apr-2017	May-2017	June-2017	Jul-2017	Aug-2017	Sept-2017	Oct-2017	Nov-2017	Dec-2017
Mean	3.43	3.77	3.61	4.20	4.29	4.41	3.91	3.74	3.65	3.52	3.24	3.48
SD	1.27	0.96	0.96	1.05	1.03	1.03	1.16	1.13	1.28	1.34	1.23	1.15
Max	8.27	6.77	6.88	8.85	8.03	9.23	10.84	9.05	11.34	11.66	9.15	8.99
Min	0.72	1.77	1.62	1.90	0.64	2.16	1.74	1.33	0.57	0.83	0.14	− 0.05
National inflation target	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Mean arithmetic average, *SD* standard deviation, *Min* minimum amount value in observation, *Max* maximum amount in observation, National Inflation Target is in the range ± 1% of the target

(d) Inflation *year-on-year* 82 cities January-2018 to December 2018

Indicator	Jan-2018	Feb-2018	Mar-2018	Apr-2018	May-2018	June-2018	July-2018	Aug-2018	Sep-2018	Oct-2018	Nov-2018	Dec-2018
Mean	3.17	3.05	3.20	3.22	3.14	3.01	3.06	3.07	2.72	3.01	3.15	3.03
SD	1.15	1.02	1.00	0.77	0.75	0.86	1.19	0.97	1.02	1.00	1.00	1.06
Max	9.04	8.34	6.06	5.17	4.93	4.62	5.50	5.56	5.47	6.05	7.14	6.49
Min	0.30	1.21	0.44	0.68	1.31	− 0.28	− 2.60	− 0.34	− 0.86	− 1.21	1.58	0.95

Indicator	Jan-2018	Feb-2018	Mar-2018	Apr-2018	May-2018	June-2018	July-2018	Aug-2018	Sep-2018	Oct-2018	Nov-2018	Dec-2018
National inflation target	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50

Mean arithmetic average, *SD* standard deviation, *Min* minimum amount value in observation, *Max* maximum amount in observation, National Inflation Target is in the range $\pm 1\%$ of the target

Appendix 2: Unit root test

Variable	Adjusted *t*-statistic	*p* value
Inflation	− 7.6027[1]	0.000***
Interest rate	− 5.9929[2]	0.000***
Money supply (M2)	− 3.4747[3]	0.003***

***Significant at 1%; **Significant at 5%; *Significant at 10%

Augmented Dickey–Fuller Test (ADF): [1]ADF regressions: 11.00 lags average (chosen by Akaike Information Criterion (AIC)), [2]ADF regressions: 11.00 lags average (chosen by AIC), [3]ADF regressions: 11.00 lags average (chosen by AIC)

Appendix 3: The division of regions

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