Is the Phillips Curve Valid in Fintech 3.0 Era? An Error Correction Model Approach

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Abstract. The Phillips curve explains that governments' policies to control inflation will increase unemployment rates. However, financial technology (fintech) may lead to a positive relationship between inflation and unemployment. Fintech will arguably cause low inflation and unemployment rates. This study seeks to investigate the causal relationship between inflation and unemployment before and after the fintech 3.0 era and the impact of fintech 3.0 on the relationship between inflation and unemployment in Indonesia. Using the Granger causality and error correction model (ECM) tests to analyze time series data of 1985–2020, this research empirically demonstrates a one-way causality between inflation and unemployment during the fintech 3.0 implementation in Indonesia. Further, the ECM estimation indicates unemployment rate positively and significantly affects inflation rates in the long run. Thus, optimal use of fintech technology stabilizes prices and controls unemployment rates. Financial technology creates a cashless society that controls inflation.

Keywords: financial technology (fintech) · unemployment rate · inflation · granger causality · error correction model (ECM)

1 Introduction

Inflation is a serious economic problem. [1] define inflation as general and continuous increases in goods and service prices. Indonesia has experienced several very high inflation rates. First, the transition from the Old Order to New Order in 1965 witnessed more than 600% hyperinflation. The condition is likely because of the uncontrolled supply of three currencies: De Javasche Bank's banknotes which are a relic of the Dutch colonial era; banknotes and coins belonging to the Dutch East Indies from Japan, namely De Japansche Regering; and Dai Nippon's banknotes that used Indonesian language [2]. At that time, Indonesia did not have an official currency as a means of payment. Conversely, the Indonesian government has no revenue but ever-increasing expenditures, leading to hyperinflation. Second, Indonesia's inflation rate in 1998 was 77.6% because of the monetary crisis that started in Thailand. Consequently, Thailand decided to devalue their Bath. Reduced Bath values greatly affected the South East Asian area's monetary conditions [3].

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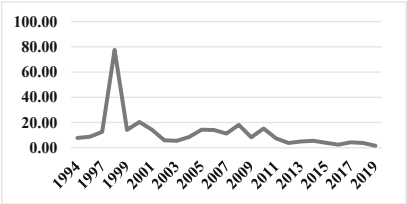

Fig. 1. Indonesia's annual inflation rates (%), 1995–2019 Source: World Bank (2022)

The 1998 monetary crisis motivated the Indonesian government to implement monetary policy with inflation as the single target, commonly known as the inflation targeting framework (ITF) monetary policy. The government started implementing the ITF monetary policy in 2005, resulting in lower and more stable inflation rates afterward. However, the 2008 financial crisis in Europe affected the Indonesian economy, as indicated by the increased inflation rate to 11.06%. Higher inflation rates reduce purchasing power and household consumption. Lower household consumption eventually affects firms as goods and services producers. Firms will arguably reduce their outputs and labor, leading to increased unemployment.

Unemployment is a condition in which an individual in the labor force does not have a job [1]. Figure 1 presents Indonesia's inflation rate in 1994–2019. It suggests that the Indonesian inflation rate increased in 2000–2005 because of increased fuel prices, especially in March and October. Fuel prices increased by 32 percent in March for premium type and 87 percent in October [4].

Fuel price increases in 2005 led to layoffs in the textile, footwear, and food industries. Besides, various fuel-reliant small businesses like traditional fishermen experienced unemployment. After increasing in 2005, the unemployment rate declined in 2006–2019 because the government has provided various financial aids since 2005, such as subsidies, social security, conditional cash transfer program (PKH – Program Keluarga Harapan), PNPM Mandiri, loan facilities for MSMEs, and people's business credit (KUR- Kredit Usaha Rakyat). According to Keynes in Putro (2016), governments' spending policies can increase aggregate demands that will enhance job opportunities and reduce unemployment. However, the unemployment rate increased again to 7.07% in 2020 due to the COVID-19 pandemic. The pandemic has encouraged many firms to lay off their

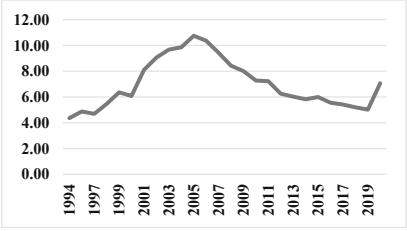

Fig. 2. Indonesia's unemployment rates (%), 1994–2019. Source: Statistics Indonesia (2022)

employees because of mounting losses, leading to much higher unemployment rates (Fig. 2).

Inflation and unemployment are two major economic problems that motivate governments to initiate macroeconomic policies to stabilize prices and create job opportunities. However, inflation and unemployment affect each other as illustrated by the Phillips curve. According to [5], A. W. Phillips published an article titled "The Relationship Between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1861–1957" in 1958, indicating a trade-off between inflation and unemployment levels as illustrated by the Phillips curve.

The Phillips curve implies that governments' inflation-controlling policies increase unemployment rates. Conversely, governments' job-creating policies to reduce unemployment increase inflation rates. For instance, higher inflation rates motivate governments, in this respect central banks, to initiate contractive monetary policies by increasing interest rates that reduce outstanding money supply as a major inflationary factor. Such policies will arguably increase production costs that encourage firms to reduce their outputs, leading to lower employment and higher unemployment rates.

Several studies demonstrate the validity of the Phillips curve in the Indonesian economy [6–8]. Other studies also indicate the validity of this curve in Malaysia [9] and 16 open-economy countries [10]. However, [11] documents no Phillips curve phenomenon in Germany. In particular, inflation and unemployment are not related in the short run. Further, [12] observe that inflation and inflation positively affect the Phillips curve in Indonesia. Meanwhile, [13] reveals no Phillips curve phenomenon in OECD countries. [14] analyze the impact of globalization and digitalization on the Phillips curve and demonstrate that globalization (digitalization) negatively (positively) affects the Phillips curve.

Financial technology (fintech) has developed rapidly. Fintech refers to digital instruments to facilitate easier financial transactions. On the one hand, fintech will increase economic activities that reduce unemployment. Lending fintech enables business actors to access financing sources in obtaining capital [15]. According to [16], the amount of loan distribution in Indonesia per September 2021 was 14,261 billion Rupiah, with the wholesale and retail sectors receiving the most productive loans (1,869 billion Rupiah or 58% of total productive loans). Easier financial access enables business actors to improve their productivity. Besides, payment fintech will expedite payment transactions, leading to more effective production processes. More efficient production processes will arguably increase job opportunities; hence, fintech can reduce unemployment rates. On the other hand, fintech improves financial service quality by reducing marginal costs and increasing non-cash payments, reducing the available money supply and inflation rates [17]. In this respect, fintech will allow a positive relationship between inflation and unemployment in the sense that fintech will create lower inflation and unemployment rates.

Numerous studies have demonstrated the validity of the Phillips curve in Indonesia, like [12, 18, 19], and [8]. However, the validity of the Phillips curve during the fintech 3.0 era remains understudied. For example, [14] examine the impacts of globalization and digitalization on the Phillips curve and document that advanced fintech changes the relationship within the Phillips curve.

2 Literature Review

A. *Philips Curve*

[5] mentions that the Phillips curve was introduced by economist A. W. Phillips. It illustrates the short-run relationship between unemployment and inflation. In the short run, unemployment and inflation are negatively related. Thus, higher (lower) unemployment rates imply lower (higher) inflation rates. According to Friedman in [5], the Phillips curve only illustrates a short-run relationship. In the long run, unemployment rates will achieve their natural levels. Natural unemployment refers to unemployment rates that will return to their original levels regardless of inflation rates.

Prior studies have investigated the causal relationship between inflation and unemployment. For example, [9] examines the existence of the Phillips curve in Malaysia by using the Vector Error Correction Model (VECM) to analyze data in 1973–2004.

[9] documents a negative causal relationship between inflation and unemployment in the long run. In other words, the Malaysian economy has a trade-off between unemployment and inflation in the long run. The findings indicate the existence of the Phillips curve theory in Malaysia.

[10] analyze the existence of the Phillips curve in OECD countries in 2015–2018 by using the static panel method and reveal a negative effect of unemployment on inflation. [18] analyzes the Indonesian data in 1984–203 using the Vector Auto Regression (VAR) method and indicates a causal relationship between inflation and unemployment, suggesting the existence of the Phillips curve in Indonesia. [19] analyzes the Phillips curve in Indonesia for the 2000Q1-2010Q3 period by using the ordinary least square (OLS) and generalized method of moment (GMM) methods and indicates a negative relationship between inflation and unemployment rates. Thus, the Phillips curve is still valid in Indonesia. [20] analyzes the Phillips curve in ASEAN countries for the 2003–2017 period using the panel data regression method and demonstrates a negative relationship between the unemployment and inflation variables. The results suggest the existence of the Phillips curve in ASEAN countries. [8] investigate the existence of the Phillips curve in Indonesia for the 2013–2017 period by using the Granger causality method. They establish a one-way causal relationship between unemployment and inflation in Indonesia, indicating the presence of the Phillips curve in Indonesia. [7] analyze the Phillips curve in high-income countries for the 1990–2014 period using the panel data analysis method. They discover a two-way relationship between unemployment and inflation both in the short and long runs. The findings indicate the existence of the Phillips curve in these countries.

[1] analyze the effect of inflation on unemployment in North Sumatra in 2003–2019 by using the multiple linear regression method. Their results support the Phillips curve theory, suggesting that in the short (long) run inflation rate negatively (positively) affects unemployment. [6] examines the Phillips curve in Indonesia in 1974Q1-2002Q4 by using the hybrid method, documenting the negative effect of inflation on unemployment. The hybrid method incorporates all factors that non-linearly affect the Phillips curve. The findings imply the presence of the Phillips curve in Indonesia. [12] analyzes the Phillips curve in Indonesia in 1986–2017 using the OLS method, revealing that unemployment rates positively affect inflation. Thus, their findings are contradictory to the Phillips

curve. [21] utilizes the VAR method in 1996–2018 and shows no causal relationship between inflation and unemployment in Indonesia, as suggested by the Phillips curve. [11] analyzes the Phillips curve in Germany by using the ordinary least square (OLS) and error correction model (ECM) in 1970–2012. They find no short-run relationship between inflation and unemployment. However, inflation and unemployment are related in the long run, conflicting against the Phillips curve. [13] analyzes the Phillips curve in OECD countries using the Granger causality method in 1990–2014 and documents a positive relationship, implying no Phillips curve phenomenon in those countries.

B. *Financial Technology*

Financial technology (fintech) refers to the use of technology in the financial sector. Fintech is the use of technology in the financial system to deliver services or business models that affect monetary stability and the efficiency of payment systems [22]. Fintech has been present since 1866 and continues to evolve today. The following are fintech evolution according to [23]:

1) *Fintech 1.0 (1867–1967): From Analogue to Digital*

This initial stage witnessed the presence of abacus to facilitate easier financial transactions. Other technologies like telegraph supported the financial system in processing transactions more quickly. In this phase, International Business Machine (IBM) introduced computerization and the first handheld calculator. The last years of this phase are also marked by the introduction of credit cards in 1950.

2) *Fintech 2.0 (1967–2000s): Digitalization of Financial Services*

Electronic payment systems developed rapidly in 1960–1970. In 1967, Automated Teller Machine (ATM) was first introduced. Starting from this year until 1987, financial services have shifted from analog to digital, from telegraph to electronic systems like interbank payments. E-banking was also introduced in 1980, and mobile phones in 1983. This phase also witnessed the internet (dot.com) bubble. Lastly, this phase marked the emergence of the internet based on the World Wide Web (WWW).

3) *Fintech 3.0 (2000 to present): Digital Financial Services*

The Fintech 3.0 era offers P2P (peer-to-peer) lending services, a shift from e-banking to m-banking, smartphones that facilitate better access to financial services, and virtual money like Shopee Pay, Gopay, Dana, and others.

C. *Fintech and Phillips Curve*

Fintech refers to digitalized financial services. According to [14], digitalization directly affects inflation. The uses of digital money affect the outstanding money supply. In turn, money supply affects money velocity and eventually increases inflation. In other words, digital money motivates consumers to continuously increase their consumption, thus increasing inflation [24].

3 Research Methods

A. *Data Types and Sources*

This quantitative study utilizes time-series data with the observation period of 1990–2020. In particular, we use the inflation and unemployment data from the International Monetary Fund (IMF) and World Bank. Further, the Fintech 3.0 variable represents the Fintech 3.0 era, with 1985–1999 being the pre-Fintech 3.0 era and 2000–2020 being the post-Fintech era.

B. *Analytical Technique*

This study utilizes the causality method with the Granger causality model. This model determines the correlation between variables [25].

1) *Granger Causality Model*

$$INF_t = \sum_{i=1}^{n} \alpha_i \, UNMP_{t-i} + \sum_{j=1}^{n} \beta_j \, INF_{t-j} + u_{1t} \tag{1}$$

$$UNMP_t = \sum_{i=1}^{n} \lambda_i \, UNMP_{t-i} + \sum_{j=1}^{n} \delta_j \, INF_{t-j} + u_{2t} \tag{2}$$

Where UNMP is the unemployment rate and INF is inflation while u_{1t} and u_{2t} are error terms that are assumed to be not correlated. According to [25], there are four possible causal relationships, namely:

1. One-way causality from the INF variable to UNMP exists when the estimated coefficient of INF in Eq. (1) is statistically different from zero, and the group coefficients of UNMP in Eq. (2) are zero.

$$\sum_{i=1}^{n} \alpha_i \, INF_{t-i} \neq 0 \; and \; \sum_{i=1}^{n} \lambda_i \, UNMP_{t-i} = 0$$

2. One-way causality from the UNMP variable to INF exists when the coefficient of INF in Eq. (1) is statistically not different from zero, and the group coefficients of UNMP in Eq. (2) are different from zero.

$$\sum_{i=1}^{n} \alpha_i \, INF_{t-i} = 0 \; and \; \sum_{i=1}^{n} \lambda_i \, UNMP_{t-i} \neq 0$$

3. Bilateral causality between the INF and UNMP variables exists when the group coefficients of INF and UNMP are statistically different from zero in both equations.

$$\sum_{i=1}^{n} \alpha_i \, INF_{t-i} \neq 0 \; and \; \sum_{i=1}^{n} \lambda_i \, UNMP_{t-i} \neq 0$$

4. No causality between the INF and UNMP variables or between UNMP and INF exists when the group coefficients of INF and UNMP are not significant in one regression equation.

$$\sum_{i=1}^{n} \alpha_i \, INF_{t-i} = 0 \; and \; \sum_{i=1}^{n} \lambda_i \, UNMP_{t-i} = 0$$

This study seeks to investigate the relationship between inflation and unemployment rates within the fintech 3.0 framework that started in 2000. Thus our model is classified into two periods:

1. Pre-fintech 3.0 period: 1985–1999
2. Post-fintech 3.0 period: 2000–2020

2). *Error Correction Model (ECM)*

Next, we run the estimation using the error correction model (ECM) to analyze the magnitude and direction of the impact of inflation on unemployment. ECM tests whether variables exhibit long-run and short-run relationships due to inter-variable cointegration [26]. In the long run, the ECM method can be formulated as follows:

$$INF_t = \beta_0 + \beta_1 UNMP_t + e_t \tag{3}$$

where β_1 is the long-run coefficient. The following is the formula to identify the short-run coefficient:

$$\Delta INF_t = \alpha_0 + \alpha_1 \Delta UNMP_t + ECT_t + e_t \tag{4}$$

where ECT_t is the error correction term.

4 Results and Discussions

A. *Before Fintech 3.0 (1985–1999)*
1) *Stationarity Test*

We run the stationarity test before the Granger causality test to identify whether the data is stationary by using the Augmented Dickey-Fuller indicator (ADF). The stationarity tests for the inflation and unemployment variables use the unit root test.

Table 1. Stationarity Test Using Augmented Dickey-Fuller (ADF)

Variable	Unit Root Test	Mac-Kinnon Critical Value (5%)	ADF	Stationarity
INF	Level	-3.0989	-3.4321	Stationary
UNMP	Level	-3.0989	0.2974	Not Stationary
	First Difference	-3.1199	-3.2272	Stationary

Table 1 demonstrates the results of the stationary test using ADF as the indicator. The results suggest that the INF variable is stationary in the level while the UNMP is stationary in the first difference.

2) *The Lag Length Test*

The lag length test identifies the best lag based on the LR, FPE, AIC, SC, and minimum HQ values. Table 2 displays that lag 4 is the best lag. This study then uses lag 4 in running the Granger causality test.

3) *Granger Causality Test before Fintech 3.0*

Table 3 shows the results of the Granger causality test by including lag 4 as the optimum lag. Because the probability value (p-value) is greater than the significance level of 5%, the unemployment variable does not affect inflation. Similarly, inflation does not affect unemployment rates before the fintech 3.0 era. In other words, there is no causal relationship between inflation and unemployment in the pre-fintech 3.0 era.

B. *Fintech 3.0 Era (2000–2020)*
1) *Stationarity Test*

Table 4 demonstrates the stationarity test by using the unit root test for each variable. The table suggests that the inflation and unemployment variables are not stationary in their levels, thus requiring further stationarity tests in the first difference level. Further tests find that both variables are stationary in their first difference levels. We then proceed with the determination of optimal lag length (Table 4).

Table 5 presents the test results to determine the optimum lag, as indicated by LR, FPE, AIC, SC, and lowest HQ values. The results suggest that lag 3 is the best lag, and we then run the Granger causality test with lag 3.

Table 2. Lag Length Determination

Lag	LR	FPE	AIC	SC	HQ
0	NA	795.0571	12.3532	12.4255	12.3076
1	17.3522	193.2490	10.9114	11.1285	10.7746
2	0.83782	390.2431	11.4991	11.8608	11.2710
3	9.82216	95.3664	9.7708	10.2772	9.4516
4	15.0734*	0.2511*	2.9614*	3.6125*	2.5510*

Table 3. The Results of Granger Causality

Null Hypothesis	Obs.	F-Statistic	Prob.
UNMP does not cause INF	11	11.7460	0.0800
INF does not cause UNMP	11	12.5185	0.0753

Table 4. The Results of Stationarity Test with Augmented Dickey-Fuller (ADF)

Variable	Unit Root Test	Mac-Kinnon Critical Value (5%)	ADF	Stationarity
INF	Level	-3.029970	-1.6039	Not Stationary
	First Difference	-3.029970	-5.8092	Stationary
UNMP	Level	-3.020686	-0.6065	Not Stationary
	First Difference	-3.029970	-3.8861	Stationary

Table 5. Lag Length Determination

Lag	LR	FPE	AIC	SC	HQ
0	NA	28.1881	9.0144	9.1134	9.0281
1	36.8265	3.7973	7.00377	7.3006	7.0447
2	5.05007	4.1123	7.0598	7.5544	7.1280
3	14.1203*	1.8798*	6.2205*	6.9130*	6.3160*

2) *Granger Causality Test*

Table 6 displays the results of the Granger causality test in the post-fintech 3.0 era. This table indicates a one-way relationship, i.e., unemployment affects inflation as indicated by the probability value of 0.004, which is lower than the significance level of 5%. Thus, the results suggest that unemployment affects inflation but not vice versa. The findings are in line with [8, 12], and [10] who document a one-way relationship (unemployment affects inflation).

The Granger causality test shows one-way causality between inflation and unemployment in the fintech 3.0 era, i.e., unemployment affects inflation in Indonesia. This study then runs the error correction model (ECM) estimation to identify the magnitude and direction of the effect of unemployment on inflation in the post-fintech 3.0 era, both in the short and long runs. However, we need to run the cointegration test to identify the long-term relationship between inflation and unemployment.

Table 7 presents the results of the Johansen cointegration test, suggesting that the probability values are lower than the significance levels of 5%. Hence, there is a cointegration or long-term relationship between the inflation and unemployment variables.

Table 6. The Results of Granger Causality

Null Hypothesis	Obs	F-Statistic	Prob
UNMP does not cause INF	18	24.4200	0.00004
INF does not cause UNMP	18	1.0736	0.40000

Table 7. The Results of the Johansen Cointegration Test

Null Hypothesis	Eigenvalue	Trace Statistic	5% Critical Value	Prob
Unrestricted Cointegration Rank Test (Trace)				
None	0.689604	24.04088	15.49471	0.0020
At most 1	0.216719	4.152490	3.841466	0.0416
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
None	0.689604	19.88839	14.26460	0.0058
At most 1	0.216719	4.152490	3.841466	0.0416

3) *ECM Estimation*

This study runs the ECM estimation to identify the effect of unemployment on inflation in the short and long runs. Table 8 summarizes the ECM estimation results. The table suggests that the ECT value is negative and significant (-0.8967) in the post-fintech 3.0 era. The value implies the short-term adjustment into equilibrium takes place relatively quickly. The unemployment variable also has a probability value of 0. 8583 (higher than the significance level of 5%). Thus, the results reveal that unemployment does not affect inflation in the short-run during the post-fintech 3.0 era.

Table 8 Panel B illustrates the results of the long-run estimation. In the long run, the R-squared value is 0.4759, suggesting that the unemployment variable explains 47.49% percent of the variation in the inflation variable while the rest is explained by other variables not included in the model. The coefficient of 2.7405 with a significance level of 0.0005 ($<\alpha = 5\%$) indicates that unemployment positively affects inflation. In particular, a 1% change in unemployment will increase inflation by 2.7405% in the long run.

5 Discussions

The Granger causality test demonstrates no causal relationship between inflation and unemployment in the pre-fintech 3.0 era. The results are not consistent with [10, 18, 20], and [8]. They observe a one-way causal relationship between inflation and unemployment, where inflation negatively affects unemployment. However, our findings support [11] and [13] who document no Phillips curve phenomenon in Germany and OECD countries. Unemployment and inflation are not related likely because cash transactions still dominated the payment transactions in the pre-fintech 3.0 era. Electronic money started to exist in Indonesia in 2009, increasing the amount of available money and eventually inflation. However, short-run increases in inflation are not accompanied by increases in firms' outputs. Consequently, inflation is not related to unemployment in the short run, as suggested by the Phillips curve that unemployment is negatively related to inflation in the short run.

Table 8. The Results of Short-Run and Long-Run Estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob
Panel A. Short-run ECM				
D(UNMP)	-0.227302	1.254317	-0.181216	0.8583
ECT(-1)	-0.896711	0.173737	-5.161303	0.0001
C	-0.843820	0.705362	-1.196293	
R-squared	0.612959	Mean dependent var		-1.045179
Adjusted R-squared	0.567425	S.D. dependent var		4.729850
S.E. of regression	3.110844	Akaike info criterion		5.245146
Sum squared resid	164.5150	Schwarz criterion		5.394506
Log-likelihood	-49.45146	Hannan-Quinn criteria		5.274303
F-statistic	13.46149	Durbin-Watson stat		2.522296
Panel B. Long-run ECM				
UNMP	2.740463	0.659712	4.154027	0.0005
C	-7.148145	3.825191	-1.868703	0.0772
R-squared	0.475948	Mean dependent var		8.254561
Adjusted R-squared	0.448366	S.D. dependent var		5.799743
S.E. of regression	4.307588	Akaike info criterion		5.849026
Sum square resid	352.5509	Schwarz criterion		5.948504
Log-likelihood	-59.41477	Hannan-Quinn criteria		5.870615
F-statistic	17.25594	Durbin-Watson stat		1.310492
Prob(F-statistic)	0.000539			

The Granger causality test in the post-fintech 3.0 era demonstrates a one-way causal relationship between inflation and unemployment in Indonesia, where unemployment affects inflation. The ECM estimation results document that unemployment positively and significantly affects inflation in the long run. Our results are consistent with [12] and [1]. The findings indicate no trade-off between inflation and unemployment in the long run during the fintech 3.0 period because unemployment positively affects inflation in the long run. Lower (higher) unemployment will reduce (increase) inflation because fintech 3.0 enables faster financial transactions that will improve the efficiency of production processes. Lower unemployment rates will ensure that economic outputs (aggregate supply) meet aggregate demands and eventually control inflation.

6 Conclusions

In conclusion, there is no causal relationship between inflation and unemployment in Indonesia during the pre-fintech 3.0 period. However, there is a one-way causal relationship between inflation and unemployment during the fintech 3.0 era, where unemployment affects inflation. Unemployment rates positively and significantly affect inflation

in the long run during the fintech 3.0 period. Fintech 3.0 facilitates faster financial transactions and more efficient production processes, thus increasing economic outputs that can meet demands and control inflation rates.

Our findings imply that the Indonesian government must design policies that optimize the public uses of fintech to preserve price stability and create more job opportunities. In this respect, the government can launch programs to introduce the uses of fintech in business activities to business owners. Besides, the government needs to socialize the uses of fintech in public activities to create a cashless society. A cashless society will maintain the amount of outstanding money in the economy to control inflation.

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