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The role of foreign reserves in inflation dynamics

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Abstract

Purpose – Central banks' foreign reserve stocks in emerging markets have increased substantially in recent decades. Foreign reserves accumulation has been widely believed as a shock absorber to prevent financial crises. Meanwhile, accelerating foreign reserves might be contradictory to the monetary policy objectives. This research aims to investigate the impact of foreign reserves on the inflation dynamics.

Method – We apply the inflation-expectation augmented Phillips curve on the monthly data over the period of 2005(7) to 2020(12) in the case of Indonesia.

Findings – We show that stockpiling foreign exchange reserves indeed has an inflationary pressure impact. The central bank's intervention in the foreign exchange market is more significant in selling rather than purchasing foreign exchange. However, the non-monetary factors also play an important role in determining inflation.

Implications – Considering channels through which foreign reserves might affect inflation, our findings suggest the monetary authority should be concerned with inflationary expectations in the short term as one of the major policy-driven goals to maintain price stability in the long run.

Originality – This paper contributes to the literature on monetary policy in developing countries. Unlike other empirical studies, this research employs the inflation-expectation augmented Phillips curve and accommodates the issue of asymmetric effects of the change in foreign reserves.

Keywords – Foreign reserves, inflation, phillips curve, central bank intervention, exchange rates

Introduction

The stock of foreign reserves in most developing countries has been considerably increasing in the last two decades. Foreign reserve holdings, which reached about 5 percent of GDP on average in the 1980s, for example, have jumped to 25 percent of GDP by 2010 (Ghosh et al., 2017). Rising reserves have been widely believed as a buffer to survive any external turbulence. The size and growth of foreign reserves also act as signals of the credibility of a country's monetary policy and creditworthiness for the global financial markets (Andriyani et al., 2020). Ultimately, holding a relatively high level of foreign reserves enables to mitigate the vulnerability to speculative attacks and promotes economic growth (Cheung & Qian, 2009).

The increase in international reserves raises concerns about how developing countries manage them. The holding of large foreign reserves involves a high degree of risk. By continually preserving undervalued exchange rates, the high level of foreign reserves held by developing countries could jeopardize the stability of the international monetary system (Dadush & Stancil,

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2011; Ghosh et al., 2017; Portes, 2010). The excessive accumulation of foreign reserves also contributes to the overheating of bank loans and asset markets (Mohanty & Turner, 2006). In the macroeconomic realm, large foreign reserve holding induces higher price levels (Heller, 1976; Khan, 1979; Steiner, 2010).

From the point of view of researchers, the trade-off between financial stability and foreign reserves is interesting. Some economists argue that the accumulation of foreign reserves growth might result in instability pressures if the resulting monetary expansion is not fully sterilized and exceeds the growth of money demand (Heller, 1976; Khan, 1979; Steiner, 2010, 2017). Others postulate that the accumulation of foreign reserves does not lead to financial instability as long as the growth rate of foreign reserves accumulation does not overshoot the rate of economic growth (see for example Kruskovic & Maricic, 2015; Lin & Wang, 2009).

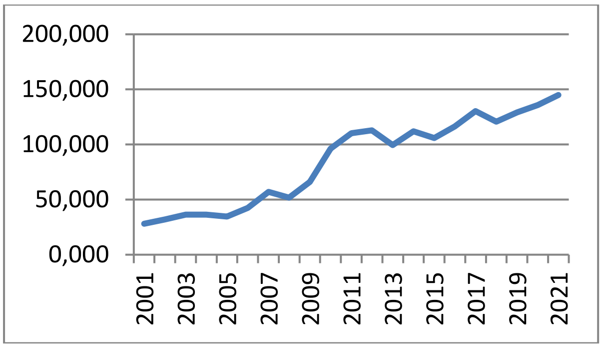
Moreover, recent empirical studies fail to explain the stabilizing role of foreign reserves in managing inflation. On the one hand, foreign reserves accumulation in some countries has no substantial effect on the inflation rate (Elhiraika & Ndikumana, 2007; Kruskovic & Maricic, 2015), a little impact (Ariyasinghe & Cooray, 2021), or even inversely related to the inflation rate (Chaudhry et al., 2011). On the other hand, many researchers find that foreign reserves strongly induce the inflation rate (Chen & Huang, 2012; Steiner, 2017; Trinh, 2015; Zhou, 2014). Losing exchange rate pass-through (ERPT) leads to the benign neglect of stabilizing the exchange rate. Therefore, foreign exchange market intervention fails to curb the exchange rate volatility (Kuncoro, 2015, 2020). Accordingly, there has been no consensus on the impacts of international reserves on the inflation rate, which needs to be further investigated.

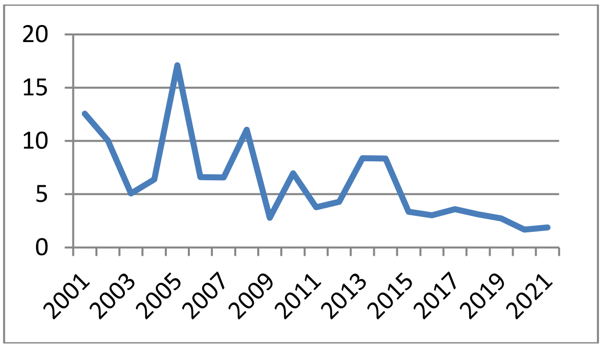
The policy makers in turn consider international reserves as a crucial issue. While inflation is one of the key macroeconomic parameters that need to be controlled, rising foreign reserves might be contradictory to the monetary policy goals. The decision to use reserves to intervene foreign exchange market appears to be increasingly driven by the 'fear of floating' rather than the 'fear of capital flight' (Calvo & Reinhart, 2002). The high degree of exchange rate pass-through (ERPT) requires the central banks to intervene more frequently in the foreign exchange market, whereas its efficacy in avoiding real exchange rate appreciation is not robust yet (Dadush & Stancil, 2011). At the same time, the high-intensity intervention has often been sterilized, instead of stabilized, resulting in systemic financial risks (Agénor et al., 2020).

Indonesia offers a good case for this reason. The foreign exchange reserves held by the Central Bank of Indonesia have continuously increased since 2000 (see Figure 1). As a country adopting a floating exchange rate system and open economy in nature, the foreign reserves accumulation is quite crucial to dampen home currency fluctuations as experienced during the 1997/98 Asian economic crisis as well as the 2008 global financial crisis. The central bank of Indonesia's international reserves skyrocketed to US$ 138 billion as of January 2021, creating a new record high at that time. The portfolio was equivalent to around 12.5 percent of GDP and could cover 10 months of imports – much greater than the conventional wisdom of a three-month minimum sufficiency standard (Jeffrey et al., 2021).

At the same time, the annual inflation rate decreased steadily and performed a long-term downward trend (Figure 1), which is in contrast to the previous decade. Following the Asian monetary crisis in 1997/98, Indonesia suffered a high inflation rate, minus economic growth, and deep currency depreciation, which has required the central bank of Indonesia to carry out economic rescue and stabilization programs. Accordingly, since July 2005 the monetary authority has been officially adopting inflation targeting in the monetary policy frameworks. All of them are directed to reaching a single goal as mandated by the new Law of the Central Bank, i.e. maintaining the stable domestic currency (Rupiah) both in terms of inflation and exchange rates.

The coincidence of the dramatic increase in foreign reserves and decrease in inflation rates raises the question of whether the relationship is in nature permanent or temporary. Knowledge of the character of inflation fluctuation under an inflation-targeting regime is very important. The larger inflation rate volatility would amplify a household's income risk and a potential output loss for business. For the central bank, the larger inflation rate volatility would reduce its policy credibility (Insukindro & Sahadewo, 2010). Eventually, the inflation shocks would worsen the whole economy using various channels. Those bring back the issue of exchange rate and foreign reserves in the discussion of inflation dynamics. The organization of this paper is structured as follows. In section 2, we describe the methodology and data used in the estimation process. Section 3 provides the estimation results and discussion of findings. Some concluding remarks are drawn in the last section.





Source: IMF, Bank Indonesia, and BPS, 2022.

Figure 1. Foreign Reserves and Inflation Rate

Research Method

Linking foreign reserves and inflation can be done in many ways, depending on the choice of the underlying theory. In this study, we employ the inflation-expectation augmented Phillips curve to empirically scrutinize the effect of foreign reserve shocks on inflationary pressures. Phillips (1958) lays the basic foundation for all inflation forecasting models. He postulates an inverse relation between wages and unemployment and, by extension, a negative relation between inflation and unemployment. The theoretical representation of an inverse relation between inflation and unemployment can be mathematically derived as:

$$\Delta p_t \equiv \pi_t = \pi_t^e + \sigma\,(\mu_t - \mu_t^e) + \varepsilon_t \qquad (1)$$

where p_t, π_t, π^e_t, μ_t, μ^e_t, and σ are the price level, inflation rate, inflationary expectations, the unemployment rate, the natural rate of unemployment, and the model parameter, respectively. Term ε_t is the shock to inflation rate and the lower-case shows the logarithmic form.

Empirically, it is exciting to identify the natural rate of unemployment and inflationary expectations, since the two particular variables are indeed unobservable. In addition, unemployment and inflation may suffer bi-directional causality, implying that they determine each other (Ho & Iyke, 2019). Two intuitions help us deal with these estimation challenges. First, we assume that the adaptive and rational expectation hypothesis holds, indicating that inflation is persistent. Second, we assume that unemployment is hysteresis, implying that steady-state unemployment is determined by past actual unemployment (see for example: Blanchard & Summers 1987).

Based on the adaptive and rational expectation hypothesis, Equation (1) is restructured by which the lags and/or first differences of inflation and unemployment are replaced with the inflationary expectations and the natural rate of unemployment (King et al., 1995). The latter can also be substituted by the output gap (the difference between actual output and its potential output). It means that all else being equal, a larger output gap or a more negative unemployment gap implying a tighter labor market would predict rising inflation over the near term. Accounting for inflation inertia and taking for back-ward looking behavior, Equation (1) can be rewritten as:

$$\pi_t = \alpha + \beta_1\,\pi_{t-1} + \beta_2\left(q_{t-1} - q_{t-1}^p\right) + \varepsilon_t \qquad (2)$$

In the conventional Phillips curve model as Equation (2), inflation is connected to the output gap and lagged values of inflation. The inclusion of lagged values allows us to capture inflation persistence. Stock and Watson (1999), among others, suggest adding several explanatory variables to the basic model to establish a generalized Phillips curve. The inflation-expectation augmented Phillips curve model used in this paper allows us to introduce exogenous international monetary sectors into the framework specification to measure supply shocks.

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 \left(q_{t-1} - q_{t-1}^p\right) + \gamma \left(\Delta\, er_{t-1} + \pi_{t-1}^f - \pi_{t-1}\right) + \varepsilon_t \quad (3)$$

where π^f_t is the inflation rate of foreign countries and Δer_t is the relative change rate of the exchange rate. The individuals are assumed to have rational expectations and set expectations before the realization of the inflation shock.

In Equation (3), there are four factors contributing to the relative change in price level: inflation expectation effect, output surprise effect, exchange rate effect, and disturbance. The inflation expectation effect depicts the current inflation as a function of the inflation expectation performed in the previous period. The second term is associated with output surprises, linking actual and potential outputs. According to Lin and Wang (2009), the exchange rate effect describes the impact of the exchange rate on the output market.

The exchange rate covers bilateral and multilateral forms. Following Kamin and Klau (2003), the multilateral real effective exchange rate (REER) is a function of the ratio of foreign prices (P^f) to domestic goods/services prices (P) as defined by the theoretical model:

$$REER = \frac{ER.P^f}{P} \quad (4a)$$

Taking into logarithmic form, Equation (4a) becomes

$$reer = er + p^f - p \quad (4b)$$

Substituting Equation (4b) to Equation (3), we ge

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 \left(q_{t-1} - q_{t-1}^p\right) + \gamma_1\, reer_{t-1} + \gamma_2\, \Delta\, er_t + \gamma_3\, \pi_t^f + \varepsilon_t \quad (5)$$

It can be demonstrated that when the coefficients on Δer, π^f, and *reer* are zero, the model falls to the traditional Phillips curve. In cases where the coefficients onπ_{t-1} and Δer_t sum to unity, the stable long-run trade-off between the level of the real exchange rate and the rate of inflation does not exist (Kamin & Klau, 2003).

Regarding the bilateral exchange rate, the central bank can influence it by intervening in the foreign exchange market. Because data on central bank operations in many cases is confidential, we use the relative change in international reserves as an indicator of the degree of market intervention. As suggested by Lin and Wang (2009), the operation of central bank intervention is expressed by an equation as follows:

$$\Delta\, er_t = k\, \Delta\, fr_t \quad (6)$$

where Δfr_t is the change rate of international reserves. The central bank could buy foreign currency in the foreign exchange market, thus increasing international reserves holding, to allow foreign currency to appreciate (or home currency to depreciate); that is $k > 0$. The complete model is then

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 \left(q_{t-1} - q_{t-1}^p\right) + \gamma_1\, reer_{t-1} + \gamma_2\, \Delta\, fr_t + \gamma_3\, \pi_t^f + \delta\, p_{t-1} + \varepsilon_t \quad (7)$$

The lagged dependent variable in level is incorporated into Equation (7) to take into account whether the habit changes over time.

Alternatively, the foreign exchange reserve (denominated in foreign currency) is transformed into domestic currency by multiplying it with the current exchange rate. It means that foreign reserves and exchange rates jointly determine the inflation rate. Since the result is still in the nominal form, it further is divided by the CPI to obtain the real term. Later we use this alternative to run the model.

The additional explanatory variables in Equation (7) may not make the predictive power of the Phillips curve better (Stock & Watson, 1999). However, incorporating an asymmetries approach -- which was developed by Shin et al. (2012) -- into the Phillips curve improves its predictive power (Salisu & Isah, 2018). To accommodate the issue of asymmetric effects, the component of the change in foreign reserves in Equation (7) is broken down into plus and minus. The non-linear inflation-expectation augmented Phillips curve model becomes:

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 (q_{t-1} - q_{t-1}^p) + \gamma_1 reer_{t-1} + \gamma_{21} \Delta fr_t^+ + \gamma_{22} \Delta fr_t^- + \gamma_3 \pi_t^f + \delta p_{t-1} + \varepsilon_t \quad (8)$$

The existence of symmetric effects will be checked by the Wald test of coefficient restriction, whether H_o: $\gamma_{21} = \gamma_{22}$ against H_a: $\gamma_{21} \neq \gamma_{22}$. The null hypothesis states that there is no different impact on the inflation rate when the central bank either buys or sells foreign currency in the foreign exchange market.

Furthermore, to identify the unobservable potential output, this study applies the Hodrick-Prescott (HP) filtering method. The HP method has been intensively used among macroeconomists to compute a smooth estimate of the long-term trend component of a series. The method was first introduced in a seminal paper (circulated in the early 1980s and officially released in 1997) by Hodrick and Prescott (1997) to analyze postwar US business cycles.

More technically, the HP filter is a two-sided linear filter that counts up the smoothed series τ of y by minimizing the variance y of around τ_t, subject to a penalty that constrains the second difference τ. The HP filter then selects s to minimize:

$$\text{the} \sum_1^T (y_t - \tau_t)^2 + \lambda \sum_2^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \quad (9)$$

The penalty parameter λ manages the smoothness of the series τ. The larger the λ, the smoother the τ. As $\lambda = \infty$, τ will be a linear trend. The default value of λ in Eviews is set to be 14,400 for monthly data.

For this study, we employ the following indicators. Inflation rate refers to the relative change in the CPI (2012=100). The foreign inflation rate is represented by the US CPI percentage change. The exchange rate is the price of the US Dollar against the domestic currency (Rupiah). As stated before, the degree of central bank intervention in the foreign exchange market will be measured by the changes in foreign reserves. Suffering chronic current account deficits, the change in foreign reserves represents the dynamics of capital and financial accounts. Due to GDP data not being available every month, we use the industrial production index (2010=100) as employed by Kuncoro (2015).

The sample periods span from 2005(M7) to 2020(M12), i.e. since the inflation targeting regime has been implemented. The total observation is 186 sample points. Most of the monthly data are taken from the central bank of Indonesia. The data on real effective exchange rates come from the publications of the Bank of International Settlement. The real effective exchange rates data are stated in the 2010 base year. The foreign price level is represented by the US CPI released by the US Bureau of Labor Statistics. Other data are obtained from the Central Board of Statistics.

Results and Discussion

It is appropriate to open our discussion by exploring the characteristics of the data. All data are transformed into logarithmic form as required by the analytical models. Table 1 presents the descriptive statistics, consisting of mean, median, and extreme (minimum and maximum) values. Each magnitude of the mean value is quite close to the corresponding median. The closeness of the mean to the median value preliminary indicates that all of the variables of interest are normally distributed.

While the distances between maximum and minimum values are relatively small, the domestic price level and foreign exchange reserves series data relatively vary. The range is 0.8 and 1.5 respectively. The dispersion of domestic price levels and foreign exchange reserves is confirmed by its standard deviation. The standard deviation-to-mean ratio of foreign exchange reserves is the highest, indicating that the corresponding data series is widely spread from its mean value. The high variability of the exchange rate, price level, and foreign exchange reserves is a common feature in many developing countries (Chițu & Quint, 2018).

Nevertheless, the Jarque-Bera test does not accept the notion of normal distribution. The null hypothesis that all the series data have a bell-shaped distribution can be rejected at a 5 percent significance level. The non-zero value of skewness (except exchange rate) confirms that each series data is asymmetrically distributed. The upper tail of the foreign reserves distribution, for example, is thicker than the lower tail. Also, the coefficients of kurtosis are less than 3 (except real effective exchange rate). They suggest that the shape of the distribution is thinner (moderate) than the normal distribution. The harmony between the distribution of series data of foreign reserves and exchange rates raises a logical question of how closely related they are.

Table 1. Descriptive Statistics

	p	p^f	er	fr	reer	q
Mean	4.63	4.57	9.32	11.37	4.52	4.73
Median	4.64	4.58	9.31	11.56	4.52	4.74
Maximum	4.95	4.70	9.70	11.83	4.63	5.06
Minimum	4.10	4.41	9.05	10.32	4.32	4.36
Std. Dev.	0.24	0.08	0.19	0.41	0.06	0.18
Skewness	-0.36	-0.21	0.13	-0.94	-0.52	-0.01
Kurtosis	1.95	2.04	1.37	2.56	3.68	1.80
Jarque-Bera	12.43	8.41	21.16	28.73	11.88	11.16
Probability	0.00	0.01	0.00	0.00	0.00	0.00
Observations	186	186	186	186	186	186

To evaluate further the synchronous movement patterns primarily among exchange rates, foreign reserves, and inflation, we compute the correlation among the series data. However, spurious correlation can arise if time series data are not stationary even if the sample is very large. We have to transform the non-stationary time series data to make them stationary. The choice of the transformation method depends on whether the time series are difference-stationary or trend-stationary (Gujarati et al., 2012). By taking the first difference, the correlation matrix is reported in Table 2.

Notably, the synchronous patterns hold between inflation rate and real effective exchange rates (0.38). It means that the increase in real effective exchange rates (home currency depreciation) is associated with the increase in the inflation rate. The synchronous patterns in the opposite direction exist between foreign reserves and the exchange rate (-0.41). Other pairwise are asynchronous, indicated by their coefficients of correlation being small and statistically insignificant. Based on the former figure, we can say that the dynamics of the exchange rate are strongly associated with the fluctuation of foreign reserves. They will be re-examined more precisely later using econometric models as specified in the previous section.

Table 2. Correlation Matrix

	π	π^f	Δ er	Δ fr	Δ reer	Δ q
π	1.00	0.07	-0.02	0.04	0.38	-0.12
π^f	0.07	1.00	-0.15	0.08	0.15	0.18
Δ er	-0.02	-0.15	1.00	-0.41	-0.63	0.05
Δ fr	0.04	0.08	-0.41	1.00	0.22	-0.02
Δ reer	0.38	0.15	-0.63	0.22	1.00	-0.11
Δ q	-0.12	0.18	0.05	-0.02	-0.11	1.00

The analysis of the correlation above neglects the causal relationship between the pair variables of interest. For this reason, the Granger (1969) causality test is employed to examine whether there is unidirectional causality of the particular pair variables. Since The Granger causality test is susceptible to the number of lagged terms used in the estimation, the optimal lag length structure of each test is selected by the LR (Log-likelihood Ratio), FPE (Final Prediction Error), and AIC (Akaike Information Criterion) criteria.

The results are reported in Table 3. The bi-directional causality exists, running from foreign reserve growth to inflation rate. This conclusion is made by using 3 and 4 lags. The *p*-values are less than 5 percent, indicating that the null hypothesis can be rejected. As explained in the literature review section, the increase in foreign reserves (or equivalently increase in the capability of the central bank to supply foreign currency in the market) makes the domestic currency appreciate and therefore reduces the inflation rate. This finding empirically seems to be supported by studies of Trinh (2015) and Zhou (2014).

The unidirectional causality does not hold for the opposite direction, that is from inflation rate to foreign reserves. It means that foreign reserve is the cause and otherwise foreign reserve is the effect. In other words, the change in foreign reserves determines the inflation dynamics, as found by Ariyasinghe and Cooray (2021) in the case of Sri Lanka. Consequently, some efforts to improve the foreign reserves can be exerted without relying too much on the inflation dynamics.

Table 3. Granger Causality Test

Null Hypothesis:	Lags	F-Stat	Prob.
Δ fr does not Granger Cause Δ p	3	4.3841	0.0053
Δ p does not Granger Cause Δ fr		2.1202	0.0994
Δ fr does not Granger Cause Δ p	4	2.8304	0.0263
Δ p does not Granger Cause Δ fr		1.9831	0.0992

Before executing our analytical model as specified in Equation (7), we observe the time series property of the variables. Ignoring the stationary time series data leads to a spurious regression (Enders, 2004; Gujarati et al., 2012). Table 4 performs the Augmented Dickey-Fuller (1979) unit roots test results for the underlying series data. The null hypothesis of the non-existence of unit roots can be accepted for the variables of domestic CPI and real effective exchange rate in level, implying the two series data are stationary. Other data are non-stationary. The non-rejection of the null hypothesis of unit roots may be the result of deterministic trend shifts.

However, the null hypothesis can be rejected even at the 1 percent significance level for all of the series data in the first differences. This indicates that after first-differencing, stationary is reached, i.e. most of the series data are integrated of order one (*I(1)*). In such a case, most of the variables in the first-difference forms are stationary. It means that the behavior of the variables moves around the mean value and is invariant over time (Enders, 2004). The non-stationary data series offers an early symptom of shocks having persistent or long-lasting effects, thus making it very hard for conventional stabilization measures to defend.

Table 4. Unit Roots Tests

	Level		First-difference		Conclusion
	t-stat	Prob.	t-stat	Prob.	
p	-3.791	0.003	-	-	*I(0)*
p^f	-0.760	0.827	-9.731	0.000	*I(1)*
er	-0.810	0.813	-10.975	0.000	*I(1)*
fr	-2.629	0.089	-11.497	0.000	*I(1)*
reer	-4.110	0.001	-	-	*I(0)*
q	-0.931	0.776	-14.631	0.000	*I(1)*

The series data stationary properties are prerequisites to establish cointegration, which is a fundamental concept for investigating the long-term behavior of the series data. Cointegration deals with the long-run analysis of the relationship among variables with the same order of integration. The speed of partial adjustment to the long-run equilibrium after a deviation is measured by the coefficient on the lagged dependent variable. Another method to verify the existence of cointegration is the Johansen (1991) multi-cointegration test.

As highlighted in Table 5, the result indicates that the null hypothesis of no cointegration at most 1 equation can be rejected. This means the presence of a long-run and stable relationship between the inflation rate and its determinants. Hence, the test ensures the existence of the cointegrating equations among the non-stationary (or stationary at the different levels) series, which denotes that the linear combinations of those series are stationary and tend to evolve towards the long-run equilibrium relationship.

Table 5. Cointegration Test

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.**
None *	0.217	136.613	103.847	0.000
At most 1 *	0.193	92.284	76.973	0.002
At most 2	0.111	53.522	54.079	0.056
At most 3	0.086	32.276	35.193	0.099
At most 4	0.052	16.049	20.262	0.172
At most 5	0.034	6.307	9.165	0.168

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

In the preceding section, we focus on the empirical results. The ordinary least squares estimation results are reported in Table 6. Estimation of Equation (7) is considered a baseline (Model (1)) and Model (2) based on Equation (8) is the extended one. As presented in Table 6, most of the estimated coefficients in the equation model are statistically significant, verified by t-statistics value exceeding the relevant t-table at 5 percent or even 1 percent significance levels. The foreign inflation rate is the only insignificant one. Statistical indicators, such as the F-test, standard error of the regression, and DW-test are sufficiently reliable. The coefficient of determination is relatively low, suggesting there are many other determinants influencing the inflation rate in Indonesia (Insukindro & Sahadewo, 2010; Juhro & Iyke, 2019).

The sign of each parameter estimated is as expected by the corresponding theory. The coefficient of the lagged inflation rate is positive, representing the speed of adjustment. As explained in the descriptive statistics analysis, all of the variables are relatively stable over the whole period of observation. Only 77 percent of any disequilibrium is gradually corrected to the desired level in a month. Given the relatively high adjustment mechanism, the inflation rate tends to be less persistent in response to any fluctuations in the short run. In addition, the coefficient of the lagged price level is quite low (0.008), indicating that the habit slowly changes over time.

Table 6. Estimation Results

	(1)		(2)	
	Coeff.	Prob.	Coeff.	Prob.
C	0.138	0.002	0.141	0.002
$\pi(-1)$	0.229	0.001	0.228	0.002
$q-q^p$	0.026	0.047	0.026	0.0504
reer(-1)	-0.022	0.026	-0.022	0.025
Δ fr	-0.037	0.013	-	-
Δ fr+	-	-	-0.044	0.073
Δ fr-	-	-	-0.028	0.325
π^f	0.139	0.409	0.125	0.471
p(-1)	-0.008	0.001	-0.008	0.001
R-sq	0.210		0.211	
Adj R-sq	0.183		0.179	
S.E.E	0.007		0.007	
F	7.843		6.706	
DW	2.087		2.085	

Furthermore, the output gap positively determines the inflation rate dynamics. A one basis point increase in the output gap induces an inflation rate of about 0.03 percent on average. The larger the actual output compared to the potential output ratio, the higher the inflation rate. In other words. the higher the inflation rate encourages the businessmen to produce more output, implying the law of supply, *ceteris paribus*. Accordingly, promoting economic growth strongly requires manipulating the inflation rate, primarily from non-monetary determinants (Juhro & Iyke, 2019). Our finding is much lower than Insukindro and Sahadewo's (2010) work. It seems that using quarterly data produces a higher parameter estimate rather than monthly data.

An interesting result is found in the case of foreign reserves. The coefficient of the corresponding variable is negative and statistically significant (as found by Chaudhry et al. (2011)). Therefore, its interpretation is somewhat tricky. The increase in foreign reserves implies that the central bank purchases foreign exchange in the market. It tends to shift the demand for foreign currency curve to the upper right. Assuming the supply of foreign currency curve remains constant, it makes the appreciation of foreign currency or equivalently the depreciation of the domestic currency.

The increase in foreign reserves also means that the supply of domestic currency increases, resulting in inflationary pressure, other things being equal. A one percent increase in the foreign reserves depreciates the home currency and further stimulates the inflation rate by about 0.04 percent on average, suggesting that the increase in monetary base triggered by foreign reserves is not fully sterilized. Although we found a negative sign, this result is consistent with the conventional wisdom that foreign reserves boost inflation as discovered by a large number of researchers.

Similar to foreign reserves, a one percent depreciation in the real effective exchange rate enhances the inflation rate by about 0.02 percent on average. This result confirms Kuncoro's (2015) finding that the bilateral ERPT does not hold for the CPI, while it does for import price and producer price indices. As a consequence, Indonesia in the inflation targeting regime loses ERPT thus leading to benign neglect of stabilizing its external value in terms of the exchange rate. In the context of a real effective exchange rate, as observed in the present study, the pass-through mechanism occurs. The international inflation and economic cycles are transmitted into domestic consumer prices through real effective exchange rate movements.

Unfortunately, splitting the relative changes in foreign reserves components into plus and minus does not provide a better result. The Wald test result, as reported in Table 7, indicates that the null hypothesis can be accepted at a 5 percent significance level. There is no different impact on the inflation rate between the increase and decrease of foreign reserves. When the relative change in foreign reserves is positive, implying the central bank sells foreign currency to the market, it affects the inflation rate reduction by about 0.04 percent on average. This result is close to the estimate obtained from Model (1).

In contrast, when the relative change in foreign reserves is negative, it does not have any effect on the inflation rate movement. The asymmetric behavior of the central bank's intervention is probably related to the low degree of ERPT as explained above. As emphasized by Adler et al. (2021), central banks in the inflation targeting adopted emerging economies have dual inflation-exchange rate objectives. They also argue that a higher propensity to overshoot inflation targets in emerging market economies in which foreign exchange intervention is more pervasive.

Table 7. Symmetric vs Asymmetric Behaviour Tests

Null Hypothesis	Test	Value	Df	Prob.	Conclusion
$\gamma_{21} = \gamma_{22}$	t-stat	-0.349	176	0.727	Ho accepted: symmetric
	F-stat	0.122	(1, 176)	0.727	
	χ^2	0.122	1	0.726	

Conclusion

Inflation rates, exchange rates, and foreign reserves are three prominent economic fundamentals in developing countries, including Indonesia. Whether or not foreign reserves affect the inflation rates is highly debatable. On the one hand, the accumulation of foreign reserves might induce instability pressures if the resulting monetary expansion is not fully sterilized. On the one hand, stockpiling foreign exchange reserves does not lead to financial instability as long as the growth rate of foreign reserves does not exceed the rate of output growth, Meanwhile, the decline in foreign reserves used by central banks to increase the supply of foreign currency in the foreign exchange market in many cases fails to control the exchange rate volatility, instead of the level of exchange rate.

This paper examines the effect of foreign reserves on the inflation rate fluctuation. The application of inflation-expectation augmented Phillips curve for Indonesia's monthly data over the period of 2005(1)-2020(12) concludes that the inflation expectation plays an important role in the actual inflation. Output gaps also contribute significantly. Accordingly, inflation in Indonesia is typically backward-looking behavior and real sector-oriented, even though monetary surprises and external effects in forming inflation expectations cannot be neglected. The international inflation and economic cycles are transmitted into domestic consumer prices through real effective exchange rate movements. The real effective exchange rate appreciation leads to an inflation rate.

Furthermore, foreign reserves remain the important determinants of inflation movements. The foreign reserves positively contribute to the inflation rate. There is no different impact on the inflation rate between the increase and decrease of foreign reserves. The expanded monetary base accelerated by foreign reserves is not thoroughly sterilized. Since the change in foreign reserves reflects the degree of central bank intervention, the impact of central bank intervention in the foreign exchange market is higher when the domestic currency appreciates rather than depreciates. It implies the inflation targeting regime implicitly has dual inflation-exchange rate objectives.

Those findings suggest the monetary authority should be concerned with inflationary expectations in the medium term as one of the important policy-driven objectives to maintain price stability in the long run. Further research is recommended to pay more attention to the central bank's intervention in the foreign exchange market. Triple intervention allows the Central Bank of Indonesia to manipulate the exchange rate in the spot market, forward market, and secondary securities market. The different central bank's intervention characteristics in each market may lead to different impacts on the exchange rate and further inflation rate. Unfortunately, data on time and how much the central bank of Indonesia intervenes in each foreign exchange market are publicly unavailable, precluding a formal analysis of the relationship among the foreign reserves, exchange rates, and inflation rates.

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