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Asymmetry in the Reaction Function of Monetary Policy in Emerging Economies

Summary: The Taylor rule is an important device to study the behavior of the central bank. Conventionally, the Taylor rule is constructed by optimizing a quadratic loss function with the constraint of a linear economic system. Accordingly, the response of interest rate is linear with respect to the sign of inflation gap and output gap. In practice, however, monetary authorities in emerging economies can depart from the linear-quadratic framework. The objective of this paper is to investigate the nonlinearity of the Taylor rule driven by either a nonlinear Phillips curve or an asymmetric preference. We use the generalized method of moments (GMM) method to investigate these asymmetries in twelve emerging economies targeting inflation. The empirical results show that deflation pressure caused by economic recessions has a stronger effect on the interest rate. Moreover, the recession avoidance preference is strong in emerging economies whereas the inflation avoidance preference only emerges in a few emerging economies such as Brazil, Colombia, Hungary, Philippines, and South Africa.

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Since 1990s, emerging economies have evolved substantially. Many of them adopted inflation targeting to fight against hyperinflation, recover the economy, and construct the credibility of the central bank. In the regime of inflation targeting, inflation reduced significantly and the economy became more stable. As a result, this framework obtained more attention from policymakers and economists. Given the success of inflation targeting, it is of interest to assess the conduct of monetary policy in these economies.

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Nevertheless, the literature about monetary policy setting is controversial. Numerous studies apply the Taylor (1993) rule to investigate the setting of monetary policy. Taylor (1993) constructs an interest rate rule by optimizing a quadratic loss function within the constraint of a linear economic system. Based on the linear-quadratic framework, later studies suggest some modifications into the conventional Taylor rule such as smoothing behaviour (Moura and de Carvalho, 2010; Svensson, 1999) or the expectation of inflation or output (Clarida et al., 1999, 2000; Clarida et al., 1998; Minella et al., 2003; Minella and Souza-Sobrinho, 2013). In these studies, the

Taylor rule is linear, meaning that monetary authorities show indifference to the sign of inflation gap and output gap.

In practice, however, monetary authorities in emerging economies show a different pattern of interest rate setting. *Blinder* (1998) pointed out that monetary authorities consider political heat more seriously when reducing interest rate to solve unemployment than when increasing interest rate to reduce inflation. By contrast, monetary authorities may prefer to anti-inflation when they concern about the building of credibility. In addition to an asymmetric preference, a nonlinear Phillips curve can justify the nonlinearity of the Taylor rule because it shows the asymmetry in the inflationary pressure caused by output changes. Because of these, the linear rule has limited use in emerging economies.

Recent studies provide increasing evidence challenging the linear-quadratic framework. In fact, the Taylor rule is nonlinear because of either a nonlinear Phillips curve (Bec et al., 2002; Dolado et al., 2005; A. Nobay and Peel, 2000; Schaling, 2004) or an asymmetric preference to negative and positive shocks of inflation and output gap (Aguiar and Martins, 2008; Bec et al., 2002; Caglayan et al., 2016; Dolado et al., 2004; Komlan, 2013; A. R. Nobay and Peel, 2003; Surico, 2007; Tawadros, 2016, 2020). Although these studies give crucial policy implications, their constraint is that they mainly focus on advanced economies.

Few studies (Aragón and de Medeiros, 2013; Aragón et al., 2016; Klose, 2019; Kobbi and Gabsi, 2019; Sznajderska, 2014; Vašíček, 2012) addressed the nonlinear Taylor rule for emerging economies, especially those in Asia or Latin America. Moreover, studies covering the post-crisis period is rather scant. The objective of this paper is to examine the implication of a nonlinear Phillips curve and an asymmetric preference for the nonlinear setting of interest rate in emerging economies that target inflation.

The paper makes several contributions to the existing literature. Firstly, we provide update evidence for the nonlinear Taylor rule in emerging economies. It extends the research horizon to cover the post-crisis period. Secondly, it extends the sample to include many emerging economies, especially those in the Asia and Latin America region, whereby there is little evidence on the nonlinear monetary policy rule. The comparative analysis gives new insights into the nonlinear setting of interest rate in emerging economies. Particularly, the geographically diversified characteristic of the sample improves the generalization of the nonlinearity in the reaction function of monetary policy in emerging economies. Thirdly, we focus on a group of twelve emerging economies adopting inflation targeting because they play an increasing role in the global economy.

The paper is organized as follows. Section 2 presents the existing literature about the effect of a nonlinear Phillips curve and an asymmetric preference on the nonlinearity of the Taylor rule. Section 3 discusses methodology and data. Section 4 presents and discusses empirical results. Section 5 concludes the paper.

LITERATURE REVIEW

In this section, we review the existing literature about departures from the linear-quadratic framework. First, we discuss the implication of a nonlinear Phillips curve as well as an asymmetric preference on the nonlinearity of the Taylor rule. Then, it explains motivations for further research on these asymmetries for emerging economies.

Monetary policy rule

The interest rate rule proposed by *Taylor* (1993) has established a long-lasting standard for the analysis of monetary policy. The Taylor rule plays a role in solving the problem of time inconsistence in the conduct of monetary policy. Accordingly, monetary policy setting closely links to economic movements. Particularly, interest rate proportionally responds to output gap and inflation gap, which are deviations of the two from their benchmark levels.

Clarida et al. (1999, 2000; 1998) and *Svensson* (1997, 1999) noted that interest rate adjustments can stabilize the economy when these adjustments are greater than changes in inflation and are positive in response to output gap. This is referred to as the Taylor principle rule. Its violation implies that monetary policy destabilizes or accommodates shocks.

Following studies suggest some modifications to the linear Taylor rule. Clarida et al. (2000) argue that monetary authorities are proactive and monetary policy decisions depend on the forecast of output and inflation. Forecasting plays an important role to deal with the uncertainty and delay in making policy decisions (Svensson, 1997, 1999).

Many studies support the forward-looking specification of the Taylor rule (Minella et al., 2003; Minella and Souza-Sobrinho, 2013).

Another modification is to consider the intention to smooth interest rate movements (Moura and de Carvalho, 2010). Such a smoothing behaviour can stem from either the dislike of market participants for large jumps or sudden reversals in the interest rate or the uncertainty related to the true analysis model and released data (Sack and Wieland, 2000).

Drivers of a nonlinear monetary policy rule

The linear economic underlying and quadratic loss function may be too restrictive to capture the complexity in the practical implementation of monetary policy. Recent studies point out that positive and negative shocks of inflation gap and output gap may not be equally important in the Taylor rule. Moreover, inflationary pressure can be different in recessions and expansions. Briefly, both a nonlinear Phillips curve and an asymmetric preference can lead to a nonlinear Taylor rule.

To begin with, the Phillips curve developed by *Phillips* (1958) is a useful tool to analyse the trade-off between output gap and inflation. Its shape has crucial implications for monetary policy conduct because it shows disinflation costs. Conventionally, the Phillips curve is linear, implying the constant cost of reducing inflation. The optimization problem of a linear Phillips curve and quadratic loss function has the solution that monetary policy rule puts equal weights on inflation and output gap. Nevertheless, later works show that the Phillips curve can be nonlinear. The Phillips curve can be convex because of price downward rigidity, capacity constraint, menu cost (Ball and Mankiw, 1994; Dotsey et al., 1999), signal extraction (Lucas, 1973), or money illusion problem in low inflationary environment (Akerlof et al., 1996). In this case, a positive inflation shock accelerates price increases. Once inflation is high, it is costly to reduce it. As a result, monetary authorities show a disinflation bias. On the contrary, the Phillips curve can be concave, though it is less popular in the literature, when monopolistic firms are more willing to decrease prices in times of weak demand to avoid takeover threat (Stiglitz, 1997). The concavity indicates high cost of increasing domestic prices. Another possibility is a hybrid Phillips

curve that combines convex and concave parts (Baghli et al., 2007). In summary, a convex (concave) Phillips curve indicates the severity of inflationary pressure caused by a positive (negative) output gap shock and thus monetary policy response to inflation should be more powerful in expansions (recessions) (Dolado et al., 2005).

Another driver of a nonlinear Taylor rule is the asymmetric preference of monetary authorities to a positive and negative shock of output gap and inflation gap. The asymmetric preference has two implications. Firstly, monetary authorities are reluctant to reduce inflation when facing political heating (Blinder, 1998; Persson and Tabellini, 1999). In fact, career-concerned policymakers react more forcefully to stimulate the economy when expecting an output contraction (Surico, 2007; Sznajderska, 2014). These support the recession avoidance preference. Secondly, monetary authorities can be averse to high inflation especially when they concern about credibility construction in the regime of inflation targeting (Sznajderska, 2014). Therefore, deflationary bias is a necessary condition to fulfil the price stability objective. Relying on the preference of monetary authorities, *Cukierman and Muscatelli* (2008) indicate that monetary authorities can show a bias to avoid high inflation or recession.

Empirical studies of a nonlinear Taylor rule

There are many studies investigating the nonlinearity of monetary policy that is conditional on a nonlinear Phillips curve or an asymmetric preference for advanced economies. Dolado et al. (2005) investigate the effect of the nonlinear Phillips curve in the US and three European countries by adding the interaction between output gap and expected inflation into the traditional Taylor rule. They find that monetary policy strongly reacts to inflation in expansions. The positive value of the interaction coefficient implies that the nonlinear Taylor rule is owning to a convex Phillips curve. By contrast, a linear rule is found for the US. *Schaling* (2004), however, documents that monetary policy is nonlinear in the US, characterized by a greater inflationary pressure in expansions than in recessions.

Caglayan et al. (2016) investigate the case of the UK and Canada over the period 1883 to 2007. Based on a linex loss function, they add the square of inflation and output volatility into the traditional Taylor rule. They find that the preference is different in these countries. While inflation avoidance is strong in the UK, recession avoidance is strong in Canada. Using a similar approach, Dolado et al. (2004) augment the conditional variance of inflation to investigate the asymmetric preference to inflation in the US from 1970 to 2000. Their results emphasize the inflation avoidance preference. *Surico* (2007) applies the linex function for both inflation and output gap and suggests that the nonlinearity of the Taylor rule can be examined by observing the squared value of inflation and output gap. The GMM estimates show that the Fed puts a greater weight on negative output gaps, implying the fear of recession.

In addition to using a linex loss function, many other studies use threshold models to examine the implication of an asymmetric preference. *Bec et al.* (2002) use this method to investigate the nonlinear Taylor rule for US, France, and Germany. They find that monetary authorities in the US and Germany are averse to inflation only in expansions whereas Bank of France strongly responds to inflation in recessions. Cukierman and Muscatelli (2008) use smooth transition regressions and find evidence for the asymmetric preference in the UK and US. In the UK, recession avoidance

dominates in the period prior inflation targeting but inflation avoidance dominates afterwards. In the US, the preference is time-varying. *Aguiar and Martins* (2008) study the asymmetric preference to inflation, output, and interest rate and find the relevance of the inflation avoidance preference. Particularly, monetary authorities in the Euro area put a weight of double size on the inflation rate above 2 percent. *Tawadros* (2016) uses a dummy that indicates recessions and expansions to investigate the nonlinear Taylor rule in Australia. The author finds that monetary policy is nonlinear because of an asymmetric preference rather than a nonlinear Phillips curve. However, it should be noted that the asymmetry with respect to inflation gap, output gap, or both depends on measures of inflation. Recently, Tawadros (2020) uses the inflation rate differential as a threshold variable and finds that monetary policy response is strong in the period of low inflation or recessions. *Komlan* (2013) investigates the case of Canada and finds that monetary policy is more averse to a positive inflation gap.

In contrast to the vast literature for developed countries, little is known about the effect of a nonlinear Phillips curve and an asymmetric preference on the nonlinearity of the Taylor rule in emerging economies. *Aragón et al.* (2016) find that in Brazil there is a deflationary bias when the economy is quickly expanding. The finding implies that the nonlinear rule is driven by a convex Phillips curve. On the other hand, Aragón and de Medeiros (2013) argue that monetary policy in Brazil can be nonlinear due to the asymmetric preference. They find evidence for deflationary aversion in the period prior mid-2003 and inflation aversion afterwards. *Sznajderska* (2014) uses the threshold model to investigate whether the nonlinear Taylor rule in Poland stems from either an asymmetric preference or a nonlinear Phillips curve. The empirical results indicate that interest rate response is stronger to a positive inflation gap but is weak to a positive output gap. *Kobbi and Gabsi* (2019) conduct a similar study for Tunisia. The Taylor rule includes additional variables that capture the effect of two drivers. The empirical results indicate that the asymmetric preference is the main driver of a nonlinear policy rule in Tunisia. While deflationary avoidance dominates the period prior 2011, recession avoidance appears after 2011 only.

Furthermore, there is a dearth of studies conducting a comparative analysis for a group of emerging economies. *Vašíček* (2012) focuses on Czech Republic, Hungary, and Poland. Observing the interaction term between inflation gap and output gap, the study finds weak evidence for the nonlinearity driven by a nonlinear Phillips curve in Czech Republic. To investigate the implication of an asymmetric preference, Vašíček (2012) uses both the square of variables (inflation gap, output gap, or interest rate gap) and threshold models. The study finds that inflation avoidance is visible in Czech Republic and recession avoidance is dominant in Hungary. *Klose* (2019) conducts a similar study for five Eastern European countries. The study examines the nonlinear Taylor rule by observing the squared value of inflation gap and output gap in four regimes of output gap and inflation gap. The nonlinearity evidence is mixed for five countries. Particularly, both recession and inflation avoidance are visible in Poland only and deflationary avoidance appears in other countries. The study also suggests that the nonlinearity depends on the state of the economy.

METHODOLOGY AND DATA

In this paper, we depart from the two primary assumptions of the traditional Taylor rule, which are a linear Phillips curve

and a quadratic loss function. We discuss the specification that can be used to investigate the implication of the two drivers for the interest rate setting.

Nonlinear monetary policy rule

The paper investigates the nonlinear Taylor rule that is owning to either an asymmetric preference or a nonlinear Phillips curve. Following Dolado et al. (2005), we examine the effect of a nonlinear Phillips curve by interpreting the estimated interaction coefficient (α_3) between expected inflation gap and output gap *(Equation 1)*. If $\alpha_3 > 0$, monetary policy strongly responds to inflation in expansions and the nonlinearity is conditional on a convex Phillips curve. If, however, $\alpha_3 < 0$, the nonlinear Taylor rule is conditional on a concave Phillips curve.

$$i_t = \alpha_0 + \rho i_{t-1} + \alpha_1 \pi_{t+k} + \alpha_2 y_t + \alpha_3 \pi_{t+k} y_t + \alpha_4 e_t + v_t \quad (1)$$

where i_t is the short-term interest rate, a measure of monetary policy. π_{t+k} and y_t are inflation gap and output gap, which are the primary explanatory variables of the Taylor rule. e_t is the exchange rate. v_t is the exogenous shock of monetary policy.

On the other hand, we apply the methodology developed by Caglayan et al. (2016) to investigate the effect of an asymmetric preference on interest rate setting. Accordingly, the preference to inflation or recession avoidance can be investigated by observing the significance and sign of the conditional volatility of inflation ($\sigma^2_{n,t}$) and output ($\sigma^2_{y,t}$). As shown in *Equation (2)*, a positive and statistically significant indicates the inflation avoidance whereas a negative and statistically significant suggests the recession avoidance.

$$i_t = \beta_0 + \rho i_{t-1} + \beta_1 \pi_{t+k} + \beta_2 y_t + \beta_3 \sigma^2_{\pi,t} + \beta_4 \sigma^2_{y,t} + \beta_5 e_t + v_t \quad (2)$$

The Taylor rule specified in Equation (1) and (2) shows three extensions into the traditional Taylor rule. Firstly, it incorporates the lag of interest rate to reflect the intention to smooth interest rate movements. The extension indicates that monetary authorities dislike large adjustments in the interest rate. Gradual interest rate adjustments allow market participants time to adapt to monetary policy changes. Secondly, it adds the exchange rate to capture the effect of external forces on the domestic economy. Thirdly, the Taylor rule is augmented with regressors that measure the effect of a nonlinear Phillips curve and an asymmetric preference on interest rate setting.

Data

The sample contains twelve emerging economies targeting inflation: Brazil, Chile, Colombia, Mexico, Hungary, Poland, Romania, Turkey, Korea, Philippines, Thailand, and South Africa. The data spans from January 2000 to June 2018. They are collected from well-known sources. Variables such as consumer price index and industrial production index are derived from the International Monetary Funds. Nominal effective exchange rate is mainly collected from the International Monetary Fund excepting for Turkey, Korea, and Thailand whereby the variable is derived from the Bank for International Settlements. Furthermore, output gap is determined by the spread between actual output and potential output derived from the Hodrick–Prescott filter. Inflation gap is calculated by subtracting the inflation target from the actual inflation rate. The volatility of output and inflation is the conditional

variance derived from the GARCH(1,1) estimation.

Estimation method

To estimate the nonlinear Taylor rule, we use several unobserved variables such as output gap, inflation gap, inflation volatility, and output volatility. Furthermore, inflation expectation is not readily available in emerging economies. Therefore, we use the ex-post value of inflation to replace its expectation. This remedy introduces the forecast error, leading to the endogeneity problem. Hence, we apply the GMM method because it can solve the correlation between some regressors and the error term. The GMM method also has the advantage of correcting the problem of autocorrelation and heteroskedasticity. In line with Kobbi and Gabsi (2019), we use the Newey-West procedure to correct the variance-covariance matrix.

In our estimation, inflation gap and output gap are considered as endogenous whereas exchange rate is considered as exogenous. Instruments are lags of endogenous and exogenous variables. Following Sznajderska (2014), we use the statistical significance of coefficients, the suitable signs of variables of interest, and the proper size of Hansen J statistics. The Hansen J statistic is used to test the validity of selected instruments. It should be large enough (greater than 5%) to support the validity of instruments (Baum et al., 2007).

EMPIRICAL RESULTS

This paper is one of few studies that provide comparative evidence for the nonlinear Taylor rule between emerging economies targeting inflation. We provide two sets of empirical results. Firstly, we provide preliminary results of a nonlinear Phillips curve and its implication for the nonlinear Taylor rule. Secondly, we investigate whether monetary authorities in emerging economies have an asymmetric preference to the sign of inflation gap and output gap.

Nonlinear Phillips curve and monetary policy reaction function

This session preliminarily examines the nonlinearity of the Phillips curve, which indicates an inflationary pressure caused by output changes. *Table 1* present the estimation of a simple specification of a nonlinear Phillips curve, $\pi_t = c_0 + c_1\pi_{t-1} + c_2 y_k + c_3 y_k^2 + v_t$. The main interest is to investigate the sign and significance of the squared output gap coefficient. If $c_3 > 0$, the Phillips curve is convex. In this case, the inflationary pressure in expansions will be larger than what is implied by a linear Phillips curve. By contrast, if $c_3 < 0$, the Phillips curve is concave and thus the inflationary pressure in expansions will be lower than the linear case.

As shown in Table 1, the Phillips curve is not linear in emerging economies. The Phillips curve is concave in ten out of twelve emerging economies. The finding supports the argument of *Stiglitz* (1997) about the downward flexibility of prices. In emerging economies, the monopoly encourages firms to reduce prices in time of recessions and thus monetary policy response should be stronger when output gap is negative. On the other hand, the Phillips curve is convex in Poland and Philippines. It suggests that in these economies, monetary policy response should be strong in expansions. In brief, the strong evidence for the concavity suggests that monetary policy response to inflation is stronger when facing recession pressures.

Table 1

ESTIMATION OF THE NONLINEAR PHILLIPS CURVE IN EMERGING ECONOMIES

	k	c_0	π_{t-1}	y_k	y_k^2
Brazil	6	0.194*** (0.031)	0.647*** (0.046)	–0.001 (0.005)	–0.001* (0.001)
Chile	3	0.185*** (0.039)	0.464*** (0.092)	0.018** (0.007)	–0.002* (0.001)
Colombia	9	0.466*** (0.170)	0.436*** (0.130)	0.060 (0.045)	–0.024* (0.014)
Mexico	8	0.246*** (0.045)	0.491*** (0.107)	0.000 (0.024)	–0.012* (0.007)
Hungary	7	0.195*** (0.068)	0.502*** (0.128)	0.007 (0.011)	–0.003* (0.002)
Poland	12	–0.415 (0.264)	1.084*** (0.322)	–0.013 (0.019)	0.014* (0.007)
Romania	1	0.210*** (0.071)	0.746*** (0.061)	–0.004 (0.007)	–0.002* (0.001)
Turkey	12	0.945*** (0.255)	0.974*** (0.167)	–0.123*** (0.042)	–0.016*** (0.006)
Korea	4	0.265*** (0.071)	0.738** (0.291)	–0.104*** (0.037)	–0.008*** (0.003)
Philippines	11	–0.068 (0.112)	0.439** (0.183)	0.026* (0.014)	0.004** (0.002)
Thailand	12	0.180*** (0.048)	0.386*** (0.149)	–0.024** (0.011)	–0.003* (0.002)
South Africa	11	0.397** (0.159)	0.443** (0.216)	0.108** (0.050)	–0.015* (0.009)

Notes: *, **, *** denote the significance at 10%, 5%, and 1% respectively. Standard deviation in the parentheses.

Source: Authors' estimation

Table 2 presents the nonlinear Taylor rule caused by a nonlinear Phillips curve. The coefficient on the interaction between inflation gap and output gap is the focus of the analysis and discussion. As observed, the interaction coefficient is statistically significant in most emerging economies. This gives strong evidence for the nonlinear Taylor rule in emerging economies. For Turkey, the Taylor rule seems to be symmetric.

Furthermore, the sign of the interaction coefficients varies between emerging economies. While the interaction coefficient is negative in most emerging economies, it is

Table 2

THE EFFECT OF NONLINEAR PHILLIPS CURVE ON THE TAYLOR RULE

	k	α_0	i_{t-1}	π_{t-k}	y_t	$\pi_{t-k}y_t$	e_t
Brazil	1	–0.097 (0.113)	0.992*** (0.009)	0.129*** (0.024)	0.040** (0.018)	0.037** (0.015)	0.000 (0.009)
Chile	1	0.385*** (0.088)	0.904*** (0.023)	0.086*** (0.020)	0.033* (0.017)	–0.016** (0.008)	0.005 (0.014)
Colombia	2	0.234*** (0.061)	0.953*** (0.011)	0.067*** (0.017)	0.069*** (0.017)	–0.013* (0.008)	–0.002 (0.006)
Mexico	3	0.063 (0.151)	0.959*** (0.028)	0.146** (0.070)	0.338** (0.158)	–0.130* (0.076)	–0.027 (0.018)
Hungary	1	0.108* (0.064)	0.968*** (0.015)	0.042** (0.021)	0.040** (0.017)	–0.013* (0.007)	0.026 (0.018)
Poland	1	0.140** (0.067)	0.957*** (0.017)	0.026** (0.013)	0.003 (0.008)	0.012* (0.006)	0.026** (0.011)
Romania	6	0.399*** (0.150)	0.895*** (0.032)	0.147*** (0.055)	–0.019 (0.017)	–0.011* (0.006)	0.037 (0.044)
Turkey	1	0.000 (0.093)	0.979*** (0.005)	0.076*** (0.015)	0.015 (0.014)	–0.005 (0.004)	–0.032** (0.013)
Korea	6	0.023 (0.031)	0.994*** (0.009)	0.025* (0.014)	0.014*** (0.004)	–0.008** (0.004)	0.007 (0.005)
Philippines	1	–0.011 (0.024)	1.001*** (0.005)	–0.002 (0.007)	0.005* (0.003)	0.003** (0.001)	0.008 (0.009)
Thailand	1	0.071*** (0.022)	0.968*** (0.010)	0.033*** (0.005)	0.005** (0.003)	–0.003** (0.001)	0.009 (0.006)
South Africa	5	0.064 (0.056)	0.990*** (0.008)	0.017** (0.008)	0.064*** (0.012)	–0.005* (0.003)	0.000 (0.004)

Notes: *, **, *** denote the significance at 10%, 5%, and 1% respectively. Standard deviation in the parentheses.

Source: Authors' estimation.

positive in few economies (Brazil, Poland, and Philippines). Such a finding strongly supports the nonlinearity driven by a concave Phillips curve, which is strongly connected with the preliminary results of a nonlinear Phillips curve. Accordingly, monetary policy strongly responds to inflation in recessions. This finding is contrast with the positive interaction term in Dolado et al. (2005) and Aragón et al. (2016) or the insignificant interaction term in Vašíček (2012).

Turning to other variables, their sign is strongly consistent with most monetary models. Firstly, the smoothing coefficient is

Table 3

THE EFFECT OF ASYMMETRIC PREFERENCE ON THE TAYLOR RULE

	k	β_0	i_{t-1}	π_{t+k}	y_t	$\sigma^2_{n,t}$	$\sigma^2_{y,t}$	e_t
Brazil	7	–0.127 (0.083)	0.994*** (0.007)	0.138*** (0.015)	0.062*** (0.012)	0.135** (0.057)	–18.344* (11.074)	0.015** (0.007)
Chile	1	0.321*** (0.089)	0.934*** (0.022)	0.047*** (0.012)	0.009 (0.015)	–1.969** (0.768)	–2.375*** (0.826)	0.012 (0.009)
Colombia	2	0.254*** (0.047)	0.943*** (0.010)	0.097*** (0.017)	0.017 (0.013)	1.245* (0.647)	–0.681* (0.386)	0.002 (0.006)
Mexico	1	0.217** (0.084)	0.933*** (0.019)	0.145*** (0.040)	0.094*** (0.022)	–0.148 (0.816)	4.196 (4.555)	–0.026* (0.016)
Hungary	12	0.123 (0.101)	0.957*** (0.021)	0.101* (0.057)	0.054** (0.028)	1.892* (1.094)	–3.277* (1.944)	0.032* (0.018)
Poland	1	0.247*** (0.074)	0.930*** (0.020)	0.053*** (0.016)	–0.003 (0.008)	5.380 (14.775)	0.286** (0.118)	0.030** (0.013)
Romania	1	0.688** (0.306)	0.953*** (0.031)	0.071** (0.029)	–0.021 (0.030)	–65.435* (35.764)	1.137 (1.674)	–0.008 (0.043)
Turkey	7	–0.239 (0.223)	0.980*** (0.009)	0.130*** (0.034)	0.021* (0.013)	5.584 (5.028)	–0.894** (0.445)	–0.012 (0.013)
Korea	10	0.107* (0.060)	0.984*** (0.013)	0.051* (0.026)	0.010* (0.005)	–41.175* (23.548)	0.015 (0.061)	0.004 (0.005)
Philippines	1	0.085 (0.058)	0.976*** (0.016)	0.023** (0.011)	0.001 (0.004)	0.825* (0.475)	–0.046** (0.019)	0.008 (0.011)
Thailand	1	0.105*** (0.022)	0.958*** (0.010)	0.038*** (0.005)	0.005* (0.003)	–1.264*** (0.328)	–0.170** (0.066)	0.008 (0.006)
South Africa	1	0.077 (0.063)	0.987*** (0.009)	0.011* (0.006)	0.058*** (0.008)	0.208** (0.099)	–2.258*** (0.553)	0.000 (0.004)

Notes: *, **, *** denote the significance at 10%, 5%, and 1% respectively. Standard deviation in the parentheses.

Source: Authors' estimation

statistically significant in all cases, suggesting the reluctance of monetary authorities to allow large changes in the interest rate. Such a behavior is widely documented in previous studies (Clarida et al., 2000; Dolado et al., 2005). However, the smoothing coefficient is very close to one, which can stem from the bias of omitting important explanatory variables (Rudebusch, 2006). Therefore, it is cautious to interpret the smoothing parameter. Secondly, the positive effect of output gap is significant in most emerging economies. Moreover, the size of the inflation expectation coefficient $[\alpha_1/(1-\rho)]$ is greater than unity, which obey

the Taylor rule principle. The stabilizing effect of monetary policy is consistent with Dolado et al. (2005).

Asymmetric preference and the Taylor rule

This section provides further evidence about the nonlinearity driven by an asymmetric preference. As shown in *Table 3*, the evidence for this asymmetry is mixed. To begin with, inflation asymmetry ($\sigma^2_{n,t}$) is visible in most emerging economies and it can be classified into two groups. The first group includes Brazil, Colombia, Hungary, Philippines, and South Africa. In this group, monetary policy is more aggressive to inflation rate above the target. The evidence for a disinflation bias is in line with previous studies (Aguiar and Martins, 2008; Aragón and de Medeiros, 2013; Caglayan et al., 2016; Komlan, 2013; Sznajderska, 2014; Tawadros, 2016; Vašíček, 2012). On the other hand, monetary policy in Chile, Romania, Korea, and Thailand strongly responds to inflation rate below the target. This supports the tendency to keep the pace of growth in the economy. The response is in line with Tawadros (2020) or Kobbi and Gabsi (2019).

Turning to output asymmetry ($\sigma^2_{y,t}$), it is negative and statistically significant in many emerging economies: Brazil, Chile, Colombia, Hungary, Turkey, Philippines, Thailand, and South Africa. Accordingly, monetary policy shows a stronger response to a negative output gap than to a positive output gap. This indicates the preference to avoid recession, which is consistent with Surico (2007), Vašíček (2012), Caglayan et al. (2016), and Kobbi and Gabsi (2019). The fear of economic contraction has some important implications. First, in emerging economies the central bank has little independence and thus political pressure has certain impacts on the decision of monetary authorities (Blinder, 1998; Persson and Tabellini, 1999). For Poland, the output volatility coefficient is positive, thereby monetary policy is more responsive to economic booms. The finding for Poland is not consistent with Klose (2019).

Coming to standard coefficients of the traditional Taylor rule, expected inflation and output gap have an expected effect on the interest rate in emerging economies. An increase in these variables leads to a rise in the interest rate. The response also obeys the Taylor principle, implying that monetary policy can stabilize inflation and output. The finding is in line with Klose (2019).

The results of other variables resemble those specified in section: *Nonlinear Phillips curve and monetary policy reaction function*. The smoothing coefficient is significant and close to unity. Furthermore, exchange rate changes do not have a significant effect on the interest rate. The finding has two explanations. First, the nominal effective exchange rate has a trivial effect on monetary policy setting in emerging economies. Second, monetary authorities may respond to other measures of exchange rate changes such as real effective or bilateral exchange rate. For instance, Latin America economies may strongly respond to the exchange rate against the US dollar whereas those in Europe area may strongly respond to the exchange rate against the euro.

CONCLUSIONS

In this paper, we searched for the nonlinearity in the reaction function of monetary policy in twelve emerging economies targeting price stability. Unlike previous studies, we simultaneously investigated the effect of two primary drivers of the nonlinearity: nonlinear

Phillips curve and asymmetric preference. The empirical results suggested that both have important implications for the nonlinear setting of monetary policy in emerging economies. In general, the monetary policy response to inflation is stronger in recessions than in expansions. Furthermore, recession avoidance is strong and consistent in emerging economies whereas inflation avoidance varies between economies.

In detail, monetary authorities in emerging economies show a greater aversion to deflation pressure caused by a reduction in output gap. Secondly, the asymmetric preference evidence is mixed. In Brazil, Colombia, Hungary, Philippines, and South Africa, monetary authorities aggressively reduce inflation when it is above the target. On the other hand, in Chile, Romania, Korea, and Thailand, policymakers are reluctant to keep low inflation because it can destabilize the economy. With respect to output preference, recession avoidance is strong in most emerging economies. In Poland, expansion avoidance preference is dominant.

The strong evidence for asymmetries and nonlinearities suggests important policy implications. Firstly, it causes difficulties for market participants in predicting the behavior of the central bank. In this case, clear and understandable communication plays an important role to avoid the loss of credibility in the implementation of inflation targeting in emerging economies. Secondly, market participants should account for the nonlinearity of the Taylor rule to improve the forecast of the interest rate movement. Finally, to increase the performance of inflation targeting, it is still advisable to implement monetary policy in a symmetric manner.

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