2. The Time-Varying Tradeoff between Inflation and Unemployment: Evidence from SAARC Economies with a State Space Approach

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Abstract

This paper contributes to the literature by examinig the charcetristics of the time-varying relationships between inflation and unemployment with a monthly dataset from four South Asian Association for Regional Cooperation (SAARC) economies: Sri Lanka, India, Pakistan, and Bangladesh. Employing a state space approach with Kalman filter and iterative methods, an extended canonical Phillips curve is estimated for each economy. Our empirical results reveal several new characteristics about the time-varying inflation-unemployment tradeoffs. First, all the estimated changing slopes of the Phillips curves exhibit cyclical fluctuations with different amplitutes and lengths. Second, no clear common trend was detected in the estimated time-varying tradeoffs between inflation and unemployment in these four economies. Third, the estimated slopes of the Phillips curves continued to fluctuate after 2010. Policy makers should consider these identified common and idiosyncratic charcateristics when designing macroeconomic policies in developing economies such as SAARC.

Keywords: Phillips curve, time-varying parameter model, state space approach, Kalman filter, iterative method

JEL Classification: E52, E58, E61, E23, E27

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1. Introduction

Two important goals of macroconomic policy are low inflation and low unemployment; however, these two objectives usually conflict in the short run. This tradeoff between inflation and unemployment is called the Phillips curve, while the slope of the Phillips curve measures the response of inflation to cyclical unemployment. Appropriate estimation of the slope of the Phillips curve is of particular interest to economists and policy makers.

In estimating the slope of the Phillips curve, most of the existing studies consider it as a constant parameter and focus on examining its magnitudes (Blanchard and Katz, 1997; Gorden, 1997, 2013; Brinner, 1999; Florea, 2014; Alisa, 2015). However, the recently observed puzzling coexitstence of high unemployment and high inflation has motivated researcher to reconsider whether the short-run tradeoff between inflation and unemployment is stable or not (Roberts, 2006; Williams, 2006; Gillitzer and Simon, 2015).

Moreover, as developed countries and developing economies have different cutural, institutional, and economic backgrounds (Balakrishnan *et al.*, 2011), the relationships between inflation and unemployment could exibit heterogenous characteristics in different economies. However, majority of the exisiting literature concentrate on investiagting the characteristics of the tradeoff between inflation and unemployment in the developed economies, while relatively little is known about the features of the inflation-unemployment tradeoff in the developing economies (Dayıoğlu, and Aydın, 2020; Abu, 2019; Singh and Verma, 2016 Awais, 2012; Kogid *et al*., 2011; Benigno and Ricci, 2008; Haider and Dutta, 2012).

In this paper, we examine the characteristics of the time-varying tradeoff between inflation and unemployment in four developing economies[3] by employing a state space approach with Kalman filter and iterative methods. In particular, we would examine the following questions: What are the common characteristics of the time-varying slopes of the Phillips curves? What are their idiosyncratic features? Are these characteristics similar or different from those observed for the developed economies? Understanding these questions would provide additional information to improve the design of macroeconomic policies in the developing economies.

Our paper belongs to the stream of literature that examines the features of the tradeoff between inflation and unemployment (Gorden, 1997; Brinner, 1999; Gorden, 2013; Florea, 2014; Alisa, 2015; Gillitzer and Simon, 2015), however, this reserach extends the existing studies in a few directions, which constitute the contributions of our study.

First, different from the existing literature that considers the short-run tradeoff between inflation and unemployment as either stable, or not constant, or disappeared, this paper estimates the time-varying tradeoffs between inflation and unemployment; in addition, it also concretely characterizes the features of the estimated slopes.

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[3] *We include these four developing countries: Sri Lanka, India, Pakistan, and Bangladesh into our sample because of three reasons. First, Sri Lanka, India, Pakistan, and Bangladesh are four important SAARC economies with similar institutional and economic features in Southeast Asia. Second, these four developing countries face similar risks, such as economic downturn and law issues, as highlighted by Azhar et al. (2015). Third, these four SAARC economies have been intensively studied together in the literature; for instance, Mallik and Chowdhury (2001), Nasir (2011), Anwar and Munir (2013), Zaheer (2013), and Sharif (2017).*

Second, distinct from the existing studies which mainly focus on the developed economies, this paper employs a monthly dataset from four developing SAARC economies: Sri Lanka, India, Pakistan, and Bangladesh, which would not only provide new evidence on the inflation-unemployment tradeoff, but also offer an opportunity to compare with earlier findings for other economies.

Third, different from previous investigations which mainly employ annual datasets, this paper utilizes a monthly dataset which might exhibit different time series properties (Anderson, 2000; Tsay, 2001; Zivot, 2005).

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 presents the theoretical model. Section 4 briefly explains the econometric methodology. Section 5 describes the estimation results. Section 6 discusses the policy implications, and Section 7 concludes.

2. Literature Review

The literature examing the relationship between inflation and unemployment could be roughly divided into three categories. The first stream of studies acknowledges that the tradeoff between inflation and unemployment is stable and focuses on estimating the magnitudes of the slope of Phillips curve (Goodfriend and King, 1997; Blanchard and Katz, 1997; Staiger *et al.*, 1997; Brinner, 1999; Atkeson and Ohanian, 2011; Berentsen *et al.*, 2011; Gorden, 1997, 2013; Florea, 2014; Alisa, 2015). One category of research finds that a one percent increase in inflation is associated with 0.03 to 1.30 percentage decrease in unemployment (Gordon, 1970; King and Watson, 1994; Munoli and Gani, 2016). Another category of studies shows that a one percent decrease in unemployment is associated with 0.20 to 1.60 percentage increase in inflation (Brinner, 1999; Touny, 2013; Kasseh, 2019). In particular, Staiger *et al.* (2001) find that the estimated slope coefficients of Phillips curves are stable after controlling for the univariate trends of unemployment rate and productivity growth rate. A consistent finding of this literature is that there is a significant negative association between inflation and unemployment in the short run; however, the magnitudes of the estimated slopes of Phillips curve vary with datasets and samples.

The second stream of literature finds that the inflation-unemployment tradeoff is not constant but the Phillips curve is still downward sloping (Brayton *et al.*, 1999; Kohn, 2005; Williams, 2006). Roberts (2006) finds that the slope of Phillips curve in U.S. becomes flatter and inflation rises considerably less when unemployment decreases. Through introducing a changing cost of price adjustment, Davig (2016) derived a Phillips curve with time-varying slope coefficients and showed that the systematic component of the optimal targeting rules should be the same under discretion and commitment. Moreover, Guilloux-Nefussi (2015) develops a general equialibrium framework to rationalize the flattening of Phillips curve in response to a fall in trade costs, which is consistent with the work of Matheson and Stavrev (2013) and is further empirically validated by Blanchard *et al.* (2015) and Gillitzer and Simon (2015). A common argument in this strand of literature is that the tradeoff between inflation and unemployment still exists, but it is time-varying.

The third stream of research considers that the negative relationship between inflation and unemployment has disappeared (Akerlof *et al*., 1996, 2000; Taylor, 2000). One category of research identifies a positive relationship between inflation and unemployment (Berentsen *et al*., 2011; Israel, 2015; Sasongko and Huruta, 2019). In particular, Touny (2013) finds that a one percent increase in unemployment is associated with a 1.82 percent increase in inflation in the long run. Another category of studies shows that there is no significant relationship between inflation and unemployment (Karanassou and Sala, 2010; Florea, 2014; Alisa, 2015; Wulandari *et al*., 2019). For instance, Wulandari et al. (2019) find that unemployment does not significantly affect inflation rate in Indonesia, both in the short run and in the long run. A general finding from this stream of literature is that the short-run tradeoff between inflation and unemployment does not exist any more.

The research above concentrates on examining the relationship between inflation and unemployment in the developed economies, while little is known about what happened to the inflation-unemployment tradeoff in the developing economies. Our study would contribute to the literature by empirically characterizing the time-varying tradeoffs between inflation and unemployment with a monthly dataset from the SAARC economies.

3. Theoretical Framework

In this section, we first review a canonical model that establishes the relationship between inflation and unemployment, based on the works of Blanchard and Katz (1997) as well as Katz and Krueger (1999). Then, we slightly extend it to capture the feature of the time-varying inflation-unemployment tradeoff, and this slightly extended model constitutes the foundation of our empirical analysis.

Consider a standard model of the non-accelerating inflation rate of unemployment (NAIRU), where the price equation and wage equation are specified as

$$\Delta p_t = \alpha_p + \Delta w_t + \varepsilon_{pt} \tag{1}$$

$$\Delta w_t = \alpha_w + \Delta p_t^e - \beta u_t + \varepsilon_{wt} \tag{2}$$

where: p_t and w_t are the logarithm of price P_t and nominal wage W_t, thus Δp_t and Δw_t would be the price inflation and wage inflation, respectively. u_t indicates the unemployment rate. α_p and α_w are the constant terms, while ε_{pt} and ε_{wt} represent the shocks to price inflation and wage inflation, respectively. Δp_t^e is the expected inflation at time t. Both Katz and Krueger (1999) and Blanchard and Katz (1997) adopted the static expectation hypothesis and used the lagged inflation Δp_{t-1} as a proxy for the expected inflation.

Substituting equation (2) into equation (1) delivers the expectations-augmented Phillips curve below

$$\Delta p_t = \alpha + \Delta p_t^e - \beta u_t + \varepsilon_t \tag{3}$$

where: $\alpha = \alpha_p + \alpha_w$ and $\varepsilon_t = \varepsilon_{pt} + \varepsilon_{wt}$. The natural rate of unemployment u^* is the unemployment consistent with non-accelerating inflation rate in equation (3), *i.e.*, $\Delta p_t^e = \Delta p_t$ and $u^* = \alpha / \beta$ without shocks, so the Phillips curve in equation (3) could be expressed as

$$\Delta p_t = \Delta p_t^e - \beta\left(u_t - u^*\right) + \varepsilon_t \tag{4}$$

where equation (4) indicates that price inflation Δp_t will accelerate if unemployment u_t is below the natural rate of unemployment u^* (Katz and Krueger, 1999).

It is traditionally assumed that the tradeoff between inflation and unemployment has been relatively stable over time. However, empirical researchers have documented two important facts. First, the natural rate of unemployment is time-varying (Gorden, 1997, 2013; Blanchard and Katz, 1997). Second, the slope of the Phillips curve has been changing over time (Gillitzer and Simon, 2015; Guilloux-Nefussi, 2015; Blanchard, Cerutti, and Summers, 2015; Matheson and Stavrev, 2013; Gorden, 2013; Roberts, 2006). In addition, Davig (2016) derives a Phillips curve with changing slopes by embedding state-dependent parameters into the optimal pricing problem of a monopolistically competitive firm. Therefore, it is appropriate to slightly extend the previous equation (4) by allowing its slope parameter to be varying over time

$$\Delta p_t = \Delta p_t^e - \beta_t\left(u_t - u^*\right) + \vartheta_t \tag{5}$$

where: ϑ_t is the shock to price inflation when the unemployment-inflation tradeoff is not stable. Equation (5) characterizes the changing relationships between inflation and unemployment, and this time-varying nature of the inflation-unemployment tradeoff could be one of the reasons why there is no consensus on the magnitudes of the slopes of the Phillips curves (Atkeson and Ohanian, 2001).

4. Econometric Methodology

In the time-varying Phillips curve (5), the expected inflation at time *t*, *i.e*., Δp_t^e, could not be directly observed. Following Gorden (1982), Katz and Krueger (1999), Stock and Watson (2008), and Murphy (2014), we assume that the expected inflation is a function of lags of past inflations. In particular, the lag length is set to twelve and the lagged inflation terms are equally weighted as in Murphy (2014). Thus, the estimated expected inflation is

$$\Delta \hat{p}_t^e = \frac{1}{12} \times \left(\Delta p_{t-1} + \Delta p_{t-2} + \cdots + \Delta p_{t-12}\right) \tag{6}$$

where equation (6) indicates that a sustained change in actual inflation will take one year to be fully reflected in the expected inflation. Following Blanchard *et al*. (2015) and Matheson and Stavrev (2013), we assume that the natural rate of unemployment u_t^* is equal to the average unemployment rate $\bar{u}^*$ in the sample.

The time-varying Phillips curve (5) is estimated with the state space approach (Cogley and Sargent, 2005; Primiceri, 2005; Cogley *et al*., 2005; Groen *et al*., 2013; Koop *et al*., 2009; Korobilis, 2009; Koop and Korobilis, 2012) with the Kalman filter. More specifically, the complete state space representation of our time-varying parameter model (5) is

$$\Delta p_t = \Delta \hat{p}_t^e - \beta_t\left(u_t - \bar{u}^*\right) + \varsigma_t \tag{7}$$

$$\beta_t = \rho\beta_{t-1} + \phi_t \tag{8}$$

$$\Omega_t = \begin{pmatrix} \sigma_{\varsigma}^2 & \sigma_{\varsigma\phi} \\ \sigma_{\phi\varsigma} & \sigma_{\phi}^2 \end{pmatrix} \quad (9)$$

where: (7) is the signal equation, and (8) is the state equation. The disturbance terms ς_t and ϕ_t are assumed to be serially independent and jointly normally distributed with contemporaneous variance-covariance structure indicated by (9), where σ_{ς}^2, σ_{ϕ}^2, and $\sigma_{\varsigma\phi}$, are the variances of ς_t, ϕ_t, and their covariance. ρ is the parameter to be estimated in the state equation.

Let θ be the vector of unknown parameters $\theta = \left(\rho, \sigma_{\varsigma}^2, \sigma_{\varsigma\phi}^2, \sigma_{\phi}^2\right)'$, and the log likelihood function is

$$\operatorname{Log} L(\theta) = -\frac{nT}{2}\log(2\pi) - \frac{1}{2}\sum_t \log\left|\widetilde{F}_t(\theta)\right| - \frac{1}{2}\sum_t \widetilde{\zeta}_t'(\theta)\left|\widetilde{F}_t(\theta)\right|\widetilde{\zeta}_t(\theta) \quad (10)$$

where: $\widetilde{F}_t(\theta)$ is an estimate of the prediction error variance, $\widetilde{\zeta}_t(\theta)$ is an estimate of the one-step ahead prediction error, n is the number of observational variables, and T is the time length. In estimation, we employ a sample of monthly dataset from four SAARC economies: Sri Lanka, India, Pakistan, and Bangladesh. The maximum likelihood function (10) is separately estimated with iterative methods for each of these four economies. The data analysis and estimation results are presented in the next section.

5. Empirical Results

A. Data Analysis

The monthly inflation rate is calculated from the consumer price index (CPI), which is extracted from the International Financial Statistics of International Monetary Fund. While the unemployment rate is extracted from the World Development Indicator (WDI) of World Bank, and the monthly unemployment rate is interpolated from the original annual time series with the method of Chow and Lin (1971). Our sample includes Sri Lanka, India, Pakistan, and Bangladesh, and ranges from January 1985 to December 2019.

The descriptive statistics are reported in Table 1, where we observe a few salient features. First, both the average unemployment rate and the mean inflation rate of Bangladesh are the lowest and those of Sri Lanka are the highest among the four SAARC economies. Second, the unemployment rate and inflation rate of Sri Lanka experienced the largest fluctuations, while those of India and Bangladesh had the smallest variations, respectively, in our sample. Third, the unemployment rates of Sri Lanka and Pakistan exhibit positive skewness, indicating that the right tails of their distributions are longer. Meanwhile, the unemployment rates of India and Bangladesh show negative skewness, implying that the left tails of their distributions are longer. Fourth, the right tails of the distributions of inflation rates of Sri Lanka, Pakistan and Bangladesh are longer as their skewness is positive, while the left tail of the distribution of inflation rates of India is longer as its skewness is negative.

Finally, the Jarque-Bera statistics indicate that the normal distribution assumptions of these variables are rejected even at the one percent significance level.

Table 1

Descriptive Statistics of the Variables

Stat.	UP_SK	UP_IN	UP_PK	UP_BG	IF_SK	IF_IN	IF_PK	IF_BG
Mean	8.918	5.488	5.470	3.307	0.715	0.608	0.647	0.503
Medi.	8.178	5.587	5.400	3.660	0.668	0.635	0.564	0.451
Maxi.	16.80	5.725	8.300	4.944	5.067	4.474	3.642	4.114
Mini.	3.898	4.797	3.100	1.214	-3.575	-2.120	-1.557	-2.468
St. De.	4.382	0.218	1.407	1.037	1.408	0.815	0.764	0.741
Skew.	0.471	-1.310	0.260	-0.475	0.112	-0.235	0.441	0.269
Kurt.	1.792	4.032	2.598	1.819	3.546	4.808	3.749	5.505
Ja. Be.	40.97	138.3	7.537	40.10	6.081	60.92	23.39	114.6

Notes: (1) UP_SK, UP_IN, UP_PK, UP_BG indicate the unemployment rate of Sri Lanka, India, Pakistan, and Bangladesh, respectively; (2) IF_SK, IF_IN, IF_PK, IF_BG indicate the inflation rate of Sri Lanka, India, Pakistan, and Bangladesh, respectively; (3) The statistics here are calculated using the sample from January 1985 to December 2019.

Table 2

The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Stationarity Test

Variable	Dete. Comp.	Cri. Val.**	LM-Sta.	Stationary
IF_SK	(C, T)	0.1460	0.0856	Yes
IF_IN	(C, T)	0.1460	0.1248	Yes
IF_PK	(C, T)	0.1460	0.1248	Yes
IF_BG	(C, T)	0.1460	0.1061	Yes
UP_SK	(C, T)	0.1460	0.4134	No
UP_ IN	(C, T)	0.1460	0.4297	No
UP_ PK	(C, T)	0.1460	0.5048	No
UP_ BG	(C, T)	0.1460	0.4041	No
D(UP_SK)	(C, 0)	0.4630	0.2100	Yes
D(UP_ IN)	(C, T)	0.1460	0.1124	Yes
D(UP_ PK)	(C, T)	0.1460	0.0502	Yes
D(UP_ BG)	(C, T)	0.1460	0.0670	Yes

*Notes: (1) The null hypothesis of the KPSS Lagrange Multiplier (LM) test is: the time series under consideration is stationary; (2) The exogenous variables are specified in the second column (Dete. Comp.), where C and T indicate that a constant term and a time trend are included in the test regression, while 0 indicates that only a constant is included; (3) The bandwidth is determined using the Newey-West automatic with Bartlett kernel; (4) ** comes from the Kwiatkowski–Phillips–Schmidt–Shin (1992) Table 1 at the 5% level.*

Table 3

The Breakpoint Unit Root Test

Variable	Tren. Spec.	Cri. Val.**	t-Sta.	Prob.*
IF_SK	(T, 0)	-4.8598	-9.3461	<0.01
IF_IN	(T, 0)	-4.8598	-5.3681	<0.01
IF_PK	(T, 0)	-4.8598	-8.8345	<0.01
IF_BG	(0, 0)	-4.1936	-4.2194	0.0463
UP_SK	(T, T)	-5.1757	-3.9139	0.5784
UP_ IN	(T, T)	-5.1757	-2.8351	0.9802
UP_ PK	(T, 0)	-4.8598	-3.6671	0.5859
UP_ BG	(0, 0)	-4.4436	-3.1228	0.6130
D(UP_SK)	(T,T)	-5.1757	-5.2207	0.0447
D(UP_ IN)	(T, T)	-5.1757	-7.5174	<0.01
D(UP_ PK)	(T, T)	-5.1757	-5.2989	0.0362
D(UP_ BG)	(0, 0)	-4.4436	-4.6941	0.0250

*Notes: (1) The null hypothesis of the breakpoint unit root test is: the time series being tested has a unit root; (2) The trend specification and break specification are shown in the second column (Tren. Spec.), where T indicates that a time trend is included and 0 indicates that only an intercept is included in the corresponding specifications, respectively; (3) The lag length is automatically based on Schwarz information criterion; (4) ** indicates the critical values at the 5% level; (5) * indicates Vogelsang (1993) asymptotic one-sided p-values.*

To further examine the time series properties of the variables, we conduct the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) stationarity tests and the breakpoint unit root tests. The test results are reported in Tables 2 and 3, respectively, where three salient characteristics are revealed. First, the inflation rates are stationary and do not have a unit root in all the four SAARC economies. Second, the raw unemployment rate series are not stationary and have a unit root in these four economies. Third, the first differenced unemployment rates are stationary and do not have unit root, indicating that the raw unemployment rates are integrated of order one in these four economies.

B. Estimation Results of the State Space Approach

The state space representations of time-varying Phillips curves of these economies are estimated through employing Kalman filter with iterative methods, and the initial values of the time-varying parameters β_t are obtained by estimating the standard Phillips curve. The estimation results of the state space representations are reported in Tables 4-1 to 4-4. Meanwhile, the estimated time-varying parameters β_t are plotted in Figures 1 to 4.

Table 4-1

The Estimated State Space Model for Sri Lanka

Parameters	Est. Coef.	St. Er.	z-Sta.	Prob.
Observation Equation				
σ_{ς}^{2}	2.0970	0.0644	11.495	0.0000***
$\sigma_{\varsigma\phi}$	0.0691	0.4167	-6.4133	0.0000***
State Equation				
ρ	0.9929	0. 0029	340.38	0.0000***
σ_{ϕ}^{2}	0.0003	0.7450	-11.047	0.0000***

*Notes: (1) *** indicates statistical significance at the 1% level; (2) The state space model is estimated using maximum likelihood method with OPG-BHHH/Line Search steps; (3) Convergence is achieved after 66 iterations and the coefficient covariance is computed with outer product gradients.*

Table 4-2

The Estimated State Space Model for India

Parameters	Est. Coef.	St. Er.	z-Sta.	Prob.
Observation Equation				
σ_{ς}^{2}	0.6499	0.0539	-7.9953	0.0000***
$\sigma_{\varsigma\phi}$	0.6479	0.2078	-2.0888	0.0367**
State Equation				
ρ	0.8510	0.0264	32.176	0.0000***
σ_{ϕ}^{2}	0.6712	0.4356	-0.9153	0.3600

*Notes: (1) *** indicates statistical significance at the 1% level; (2) The state space model is estimated using maximum likelihood method with Newton-Raphson/Marquart steps; (3) Convergence is achieved after 21 iterations and the coefficient covariance is computed with outer product gradients.*

Table 4-3

The Estimated State Space Model for Pakistan

Parameters	Est. Coef.	St. Er.	z-Sta.	Prob.
Observation Equation				
σ_{ς}^{2}	0.5673	0.0750	-7.5612	0.0000***
$\sigma_{\varsigma\phi}$	0.0223	1.1521	-3.3004	0.0010***

Parameters	Est. Coef.	St. Er.	z-Sta.	Prob.
State Equation				
ρ	-0.7864	0.1853	-4.2428	0.0000***
σ_{ϕ}^{2}	4.6E-11	89E+06	-2.7E-07	1.0000

*Notes: (1) *** indicates statistical significance at the 1% level; (2) The state space model is estimated using maximum likelihood method with BFGS/Marquart steps; (3) Convergence is achieved after 143 iterations and the coefficient covariance is computed with outer product gradients.*

Table 4-4

The Estimated State Space Model for Bangladesh

Parameters	Est. Coef.	St. Er.	z-Sta.	Prob.
Observation Equation				
σ_{ς}^{2}	0.4761	0.0583	-12.729	0.0000***
$\sigma_{\varsigma\phi}$	0.2031	0.1110	-14.357	0.0000***
State Equation				
ρ	0.8381	0.0191	43.866	0.0000***
σ_{ϕ}^{2}	0.0867	0.2232	-10.952	0.0000***

*Notes: (1) *** indicates statistical significance at the 1% level; (2) The state space model is estimated using maximum likelihood method with Marquardt/EViews legacy; (3) Convergence is achieved after 20 iterations.*

For Sri Lanka, three salient features about the estimated slopes of the Phillips curve are revealed from Table 4-1 and Figure 1. First of all, the estimated slopes of the Phillips curve exhibited cyclical fluctuations, while the duration of a cycle gradually became shorter and shorter as time elapsed. Second, the amplitudes of the cyclical slopes before 2010 were larger than those after 2010. Last but not the least, the estimated slopes displayed downward trend in the 1990s, which is consistent with Blanchard *et al.* (2015). However, the estimated time-varying parameters exhibited upward trend after 2000.

Concerning the time-varying Phillips curve of India, several characteristics are shown in Table 4-2 and Figure 2. First, the estimated time-varying Phillips curve also displayed cyclical fluctuations in its slopes, and the duration of one cycle is relatively stable in our sample. Second, the amplitudes of the cyclical slopes are restricted to the interval [-4.8, 7.8], which is the widest among these four economies. Third, no clear trend was detected in the estimated slopes of the Phillips curve of India.

For Pakistan, Table 4-3 and Figure 3 demonstrate a few features of its estimated time-varying Phillips curve. First of all, the cyclical fluctuations of the estimated slopes are also observed; however, the duration of one cycle is the shortest in these four economies. Second, the amplitudes of the cyclical slopes are limited to [-0.18, 0.18], which is the narrowest. Third, there is no clear trend in the estimated slopes of Pakistan's Phillips curve, which is similar as to the findings for India.

As for the estimated slopes of the Phillips curve of Bangladesh, several characteristics are revealed from Table 4-4 and Figure 4. First, the estimated slopes of the Phillips curve showed cyclical movements, while the duration of a cycle is relatively shorter as compared to that of Sri Lanka. Second, the amplitudes of the cyclical slopes are restricted to the [-1.7, 1.3] interval, which is wider than that of Sri Lanka. Last but not the least, no clear trend was identified in the estimated slopes of Bangladesh's Phillips curve, which is the same as the findings for India and Pakistan.

In summary, the estimated time-varying Phillips curves of the four SAARC economies exhibited several new common features. First of all, the estimated slopes exhibited cyclical fluctuations in the sample period, which is different from the earlier findings for the developed countries (IMF, 2009; 2013). Second, there is no clear common trend identified in the estimated slopes of the Phillips curves, which is different from the finding that the slopes had become larger after 2000 in the developed countries (Blanchard, Cerutti, and Summers, 2015). Finally, the estimated slopes of the time-varying Phillips curves continued to fluctuate even after 2010, which is different from the previous findings for the developed economies.

Figure 1

Sri Lanka

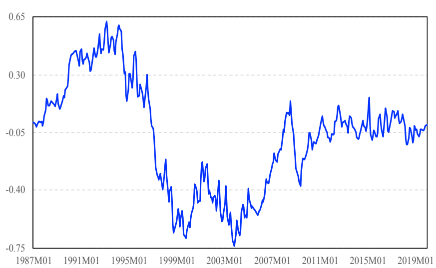


Figure 2

India

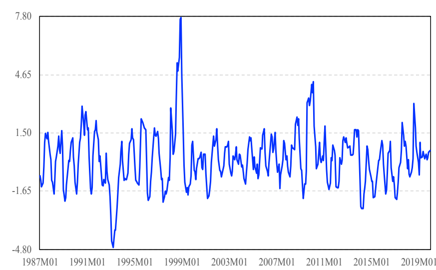


Figure 3

Pakistan

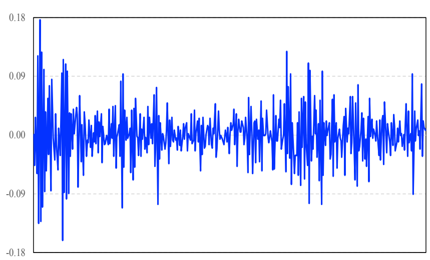
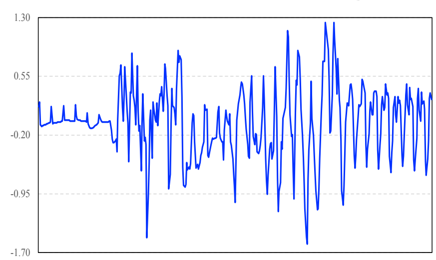


Figure 4

Bangladesh



Notes: (1) The blue lines exihibit the estimated time-varying parameter values of β_t *in the Philips curves of these four economies; (2) The estimates are statistically siginificant at the 5% level.*

4. Discussion and Policy Implication

Based on our empirical findings, what are the implications for monetary policy, fiscal policy, and other policies in the SAARC economies? We proceed to analyze this issue in this section.

First of all, as the estimated slopes of the Phillips curves exhibited cyclical movements, the policies to stabilize the macroeconomy should be adjusted according to the phases. For instance, when the estimated slopes are in the rising stage and the actual inflation is above its targeted value, government could slightly decrease its spending on hiring subsidies because a small increase in unemployment would lead to a big drop in inflation. Meanwhile, concerning monetary policy rules, higher weight can be placed on inflation target and relatively lower weight can be placed on the unemployment gap (Blanchard *et al*., 2015).

Second, as highlighted by Woodford (2003) and Blanchard *et al*. (2015), the identified downward trend of the estimated slopes of the Phillips curve in Sri Lanka in the 1990s could be owing to many factors. Guilloux-Nefussi (2015) demonstrated that a decrease in trade costs would lead to a flattening Phillips curve when the composition effect dominates the pro-competitive effect. To effectively control for inflation, government could implement certain anti-trust regulations to restrict the market power of large firms, so that the responsiveness of inflation to marginal cost shocks would be enhanced.

Third, since the estimated slopes continued to fluctuate after 2010, thus changes in inflation rates might reflect idiosyncratic shocks more likely than deviations of unemployment from its natural rates (Gillitzer and Simon, 2015); therefore, a time-varying weights on inflation targets and discretionary policies are preferred.

Finally, as no clear common upward or downward trend of the estimated slopes was identified in these economies, which is different from the findings of Blanchard *et al.* (2015) for the developed economies, macroeconomic stabilization policies should be not only economy-specific but also adjusted over time.

5. Conclusion

This paper examines the characteristics of the time-varying slopes of the Phillips curves in four SAARC economies by employing a state space approach with the Kalman filter and iterative methods.

By estimating a time-varying Phillips curve for each of the four economies, we observe that the changing tradeoffs between inflation and unemployment in the four economies exhibit several new characteristics. One of the most striking common features is the cyclical fluctuations of the estimated slopes of the Phillips curves, which is dramatically different from the previous findings for the developed economies. Furthermore, no clear common trend was identified in the estimated tradeoffs between inflation and unemployment, meaning that the slopes of the Phillips curves are not becoming larger, different from the finding of Blanchard *et al*. (2015). In addition, the estimated slopes of Sri Lanka's Phillips curve exhibit a clear downward trend in the 1990s, similar to the findings of Woodford (2003) and Blanchard *et al*. (2015), indicating that inflation became less responsive to deviations of unemployment from its natural rate in Sri Lanka in the 1990s.

Our empirical findings indicate that the time-varying tradeoffs between inflation and unemployment exhibit significantly different characteristics in the SAARC economies in comparison to those of the developed economies. Economists and policy makers need to consider the new common and economy-specific features of the time-varying tradeoffs when designing, implementing, and evaluating the monetary policy, fiscal policy, and macroprudential policies for the SAARC countries.

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