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Does the Phillips Curve Disappear after the Millennium

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Abstract: This paper uses the panel smooth transition regression (PSTR) model to reexamine the efficiency of the Phillips curve for seven efficiency-driven countries defined by the WEF (World Economic Forum) over the period from 2000 to 2010. In contrast to the Phillips curve estimated within a linear framework, the result of the LM test shows that the data used to fit the nonlinear model is superior. This empirical investigation indicates that the tradeoff relationship will disappear if the quarterly percentage change of the interest rate is between -0.70% and 14.84%, or if the ratio of government expenditure to GDP is higher than 20.92%.

Keywords: Phillips Curve, government policy, PSTR model

1. Introduction

This study reviewed the ability of the Phillips curve to fit after 2000, and explored whether monetary policy or fiscal policy is a crucial indicator of changes in the relationship between inflation rate and unemployment rate using innovation-driven countries as examples.

Lucas (1973) and Ball (1994), using a new classical and new Keynesian framework, respectively, found that the negative tradeoff relationship between the inflation and unemployment rate is supported in a closed economy. Akerlof et al. (2000) indicated that, if the inflation rate is reduced from 2% to 0%, the unemployment rate would permanently increase by 1.5%. Glocker (2012) showed that unemployment compensation can stabilize consumption and adversely affect unemployment and output.

To reexamine the robustness of the Phillips curve, Ghironi and Giavazzi (1998) included the country size as a crucial factor, and concluded that the Phillips curve is flatter in a relatively small economy. Using the new Keynesian model with imperfect information, Razin and Yuen (2002) found that the slope of the Phillips curve is smoother in an open economy. Matheson (2008) indicated that the Phillips curve exhibits inferior forecasting in an open economy compared to a closed economy.

Related literature indicated that reliance on a tradeoff relationship between the inflation rate and unemployment rate for policy purposes is challenging in the short-term. Ormerod et al. (2013) used the statistical technique of fuzzy clustering to discuss the regimes of inflation and unemployment in the United States, the United Kingdom, and Germany, and found that it is difficult to identify short-term Phillips curves.

Geske and Roll (1983) indicated that stock returns and inflation vary through fiscal and monetary policy. Cheng and Tan (2002) and Haque and Qayyum (2006) focused on monetary policy efficiency. Coibion (2012) found that monetary policy has a significant effect on real fluctuations using a standard VAR approach. To emphasize the role of government, Weise (2012) indicated that the attitude of the government is a vital element in macro variables.

We applied the PSTR model by Gonzalez et al. (2005) to re-examine the efficiency of the Phillips curve in the innovation-driven countries regarding monetary policy and fiscal policy. The remainder of this paper is organized as follows. Section II presents the characteristics of the data; Section 3 presents the methodology used to construct the measures in our empirical tests; Section 4 presents statistical tests to control monetary policy and financial policy as a threshold; and lastly, Section 5 offers a summary and conclusion.

2. Data and Summary Statistics

Our main sample consisted of seven innovation-driven countries that received high scores in innovation, as defined by the WEF, which were used to determine the completeness of data. The seven innovation-driven countries included Japan, Sweden, the United States, Germany, Denmark, Australia, and the United Kingdom. To analyze the relationship between CPI and unemployment Rate, we defined an interval of ten years after 2000. All series used in this study were balanced panel data of 308 observations from 2000:1Q to 2010:4Q. The data of innovation-driven countries were collected from the "DATASTREAM" database.

This study used two control variables, that is, the interest rate as a proxy for monetary policy and government spending to GDP as a proxy for financial policy, which may influence the relationship between the percentage change of CPI and the change of unemployment rate. Additionally, the monetary policy trend (IR_{it}) was constructed using the proxy of the quarterly percentage change of discount rate. All variables were obtained in logarithm form, and the following notations (Table 1) are used throughout the remainder of this paper.

Table 1 shows the quarterly percentage change of CPI, unemployment rate, and two control variables for the seven innovation-driven countries, as defined by the WEF, between 2000 and 2010. The average quarterly percentage change of CPI was 28.92% over the past decade. Table 1 also shows the value of the average quarterly percentage of the interest rate (-36%). The patterns from 2000 to 2010 represent the economic situation of easy money policy and positive inflation rate.

Table 1: Summary Statistics of Seven Innovation-driven Countries

	π_{it}	UNP_{it}	IR_{it}	GOV_{it}
Mean	0.2892	5.8439	-3.6397	0.2203
Median	0.3970	5.3700	0.0000	0.2156
Maximum	4.6520	12.6000	138.6294	0.2899
Minimum	-7.3283	1.70000	-147.6678	0.1531
Std. Dev.	1.2127	2.1864	24.2131	0.0397
Skewness	-2.2055	0.6481	-1.4806	0.1361
Kurtosis	16.2902	3.0812	16.3517	1.5245
Jarque-Bera	2516.45***	21.15***	2345.73***	28.23***
Cross sections	7	7	7	7

Note: This table shows the descriptive statistics of the quarterly percentage change of CPI (π_{it}) quarterly percentage change of unemployment rate (UNP_{it}), quarterly percentage change of interest rate (IR_{it}) and the ratio of quarterly change of government spending to GDP (GOV_{it}).The seven innovation-driven countries include Japan, Sweden, the United States, Germany, Denmark, Australia, and the United Kingdom. The coefficients differ significantly from zero at the 1%, 5%, and 10% levels, as denoted by ***,**, and *, respectively.

3. Methodology

This section presents the two-regime PSTR approach, which is a non-dynamic panel model developed by González et al. (2005). The PSTR model is defined as follows:

$$y_{it} = \mu_i + \alpha_0^{'} x_{it} + \alpha_1^{'} x_{it} h(q_{it};\gamma,c) + \varepsilon_{it} \tag{1}$$

where i=1,…,N, and t=1,…,T. y_{it} is the dependent variable, x_{it} is the k-dimensional vector of explicative variables, μ_i proxies the fixed individual effect, and the error term is denoted by ε_{it}. The transition function $h(q_{it};\gamma,c)$ is a continuous and bounded function of the transition variable q_{it}.The transition function $h(q_{it};\gamma,c)$ is bounded between 0 and 1 and is a continuous function of the observable variable q_{it}. Its cumulative distribution function is derived by the following formula:

$$h(q_{it};\gamma,c) = \frac{1}{1+e^{-\gamma(q_{it}-c)}}, \gamma > 0 \tag{2}$$

Following the work of Granger and Teräsvirta (1993), González et al. (2005) considered the following logistic transition function:

$$h(q_{it};\gamma,c)=\left[1+\exp\left(-\gamma\prod_{j=1}^{m}(q_{it}-c_j)\right)\right]^{-1} \text{ with } \gamma>0 \text{ and } c_1\leq\ldots\leq c_m \quad (3)$$

where $c=(c_1,\ldots,c_m)'$ is an m-dimensional vector of location parameters, and the slope of the transition function is denoted by γ, which determines the smoothness of the transitions. González et al. (2005) generalized the PSTR model to allow more than two different regimes, and constructed the additive model as follows:

$$y_{it}=\mu_i+\alpha_0'x_{it}+\sum_{j=1}^{r}\alpha_j'x_{it}h_j(q_{it}^{(j)};\gamma_j,c_j)+\varepsilon_{it} \quad (4)$$

where the transition functions $h_j(q_{it}^{(j)};\gamma_j,c_j)$, $j=1,\ldots,r$, are of the logistic type (2). The PSTR model-building procedure consists of specification, estimation, and evaluation stages. The specification includes testing homogeneity and selecting the transition variable q_{it}. A nonlinear least square method is the first step of the test procedure, which examines the linearity against the PSTR model. If the tests fail to show homogeneity, (3) is used to determine the appropriate form of transition function, i.e., the proper value of m.

The estimated model was subjected to misspecification tests to examine whether it provides an adequate data description during the evaluation stage. The null hypotheses tested at this stage included parameter constancy, remaining heterogeneity, and autocorrelation of the errors. The number of regimes in the panel model must be determined in the final step, that is, a value must be selected for r in (4).[1]

We applied the PSTR model by Gonzalez et al. (2005) to examine the relationship between the quarterly percentage change of CPI (π_{it}) and the quarterly change of unemployment rate by considering two threshold variables (Model A and Model B). In Model A, we assumed that the threshold variable is determined by the quarterly percentage change of discount rate ($\mathrm{I}R_{it}$), whereas Model B considers the quarterly change of government spending to GDP (GOV_{it}). We estimated the PSTR model as follows:

Model A: $\pi_{it}=\mu_i+\alpha_0\mathrm{UN}P_{it}+(\beta_0\mathrm{UNP}_{it})g(\mathrm{IR}_{it};\gamma,c)+\varepsilon_{it}$ (5)

Model B: $\pi_{it}=\mu_i+\alpha_0\mathrm{UNP}_{it}+(\beta_0\mathrm{UNP}_{it})g(\mathrm{GOV}_{it};\gamma,c)+\varepsilon_{it}$ (6)

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[1] For further details, see González et al. (2005) or Colletaz and Hurlin (2006).

4. Empirical results

For each model, the first step involved estimating a linear model and testing it against a model with one threshold. If the null hypothesis was rejected, a single-threshold model was estimated and tested against a double-threshold model. The process continued until the hypothesis of no additional threshold was not rejected at 1% significance. Table 2 shows the results of the linearity and specification tests of no remaining nonlinearity.

4.1. Panel Unit Root Tests

To improve the unit test low power used univariate tests, we selected IPS (Im et al., 2003) and Levin et al. (2002) as stationary tests. Table 2 shows the test result, which indicates that we rejected the null hypothesis of unit root for each variable, which ensures an I(0) type series.

Table 2: Panel Unit Root Tests

	LLC		IPS	
	Intercept and Trend	**Intercept**	**Intercept and Trend**	**Intercept**
π_{it}	-14.0965***	-14.8057***	-11.7542***	-12.7421***
UNP_{it}	-1.6871**	-4.2497***	-0.3073	-2.0792***
IR_{it}	-8.3351***	-8.9956***	-6.3756***	-7.8563***
GOV_{it}	3.4178	-0.0857	-2.1541**	-1.3629*

Note: This table shows the descriptive statistics of quarterly percentage change of CPI (π_{it}), quarterly change of unemployment rate (UNP_{it}), quarterly percentage change of discount rate (IR_{it}), and the ratio of quarterly change of government spending to GDP (GOV_{it}). LLC and IPS represent the panel root techniques by Levin et al. (2002) and Im et al. (2003). The coefficients differ significantly from zero at the 1%, 5%, and 10% levels, as denoted by ***, **, and *, respectively.

4.2. Homogeneity Test and Determining the Number of Location Parameters

Table 3 shows the result of the homogeneity (linearity) test of the PSTR model for m=1 and m= 2. The linear models were rejected in Model A for m=1 and m=2 and Model B for m=1. The optimal number of location parameters must be selected for the transition functions. We selected (m=2,r=1) and (m=1,r=1) as the optimal combinations of Model A and Model B, respectively, based on the Akaike criterion (AIC). The detailed information is shown in Table 4.

Table 3: Wald tests (LM) for Remaining Nonlinearity

Model	Model A		Model B	
Threshold Variable	IR_{it}		GOV_{it}	
Number of Location Parameters	$m=1$	$m=2$	$m=1$	$m=2$
$H_0: r=0 \; vs \; H_1: r=1$	12.362*** (0.000)	18.448*** (0.000)	3.328* (0.068)	3.328 (0.189)
$H_0: r=1 \; vs \; H_1: r=2$	0.057 (0.811)	0.603 (0.740)	0.252 (0.616)	0.171 (0.918)

Note: For each model, the testing procedure was conducted as follows: first, the linear model ($r = 0$) was tested against a model with one threshold (*r=1*). If the null hypothesis was rejected, the single threshold model was tested against a double threshold model (*r=2*). The procedure continued until the hypothesis of no additional threshold was not rejected. The corresponding LM statistic had an asymptotic x^2(mk) distribution under the null hypothesis, where m is the number of location parameters and k the number of explicative variables, that is, $k = 2$ in our specifications. The corresponding probability values are shown in parentheses. The coefficients differ significantly from zero at the 1%, 5%, and 10% levels, as denoted by ***, **, and *, respectively.

Table 4: Determination of the Number of Location Parameters

Model	**Model A**		**Model B**	
Threshold Variable	IR_{it}		GOV_{it}	
Number of Location Parameters	$m=1$	$m=2$	$m=1$	$m=2$
Optimal Number of Thresholds $r^*(m)$	1	1	1	1
Residual Sum of Squares	370.615	362.934	382.307	384.522
AIC Criterion	0.2514	**0.2405**	0.2824	0.2982

Note: For each model, the optimal number of location parameters used in the transition functions was determined as follows: for each value of m, the corresponding optimal number of thresholds, denoted by $r^*(m)$, was determined according to a sequential procedure based on the LM_F statistics of the hypothesis of non remaining nonlinearity. Thus, for each couple (m, r^*), the RSS value of the model is reported. The total number of parameters was determined by the formula $k(\gamma+1)+\gamma(m+1)$, where k denotes the number of explicative variables, that is, $k=2$ in our specifications.

4.3. Parameter Estimate for the PSTR Models

As shown in Table 5, the relationship between the unemployment rate and the percentage change of CPI changes based on the adjustment of monetary policy (discount rate) and fiscal policy movement. This indicates the importance of the role of the government in economic development, which is consistent with the results of Black (1972) and Weise (2012).

The findings shown in Table 5 and Table 6 indicate that the relationship between the unemployment rate and CPI in the middle regime from Model A is positive (0.287). It indicates that the traditional Phillips curve disappears. However, the tradeoff relationship between the inflation rate and unemployment rate is supported in the low regime and high regime. The empirical results show that the two threshold values of the percentage change of interest rate (IR_{it}) are 0.70% (C_1) and 14.84% (C_2). The results indicate that, if the average quarterly percentage change of interest rate is between -0.7% and 14.84%, that is, equal to the interval of the interest rate between subtracting one basis point and adding two basis points, the traditional Phillips Curve would be inapplicable, but remain in the outer regime. In other words, a high inflation rate and high unemployment rate would simultaneously appear if the quarterly percentage changes of interest rate are between -0.7% and 14.84%, and vice versa. This occurs in the current economy.

We further analyzed the influence of financial policy as a threshold on the relationship between the percentage change of CPI and unemployment rate from Model B. Our findings indicate that, if the ratio of government expenditure to GDP is lower than 20.92%, the Phillips curve would be ruled out, but remain supported in its outer range. Therefore, the tradeoff relationship would occur only if the ratio of government expenditure to GDP is higher than 20.92%. In other words, the Phillips curve is supported based on the financial policy shift. This is also shown in Figure 2.

Table 5: Parameter Estimates for the PSTR Models

Model	Model A		Model B	
Threshold Variable	IR_{it}		GOV_{it}	
(m, r^*)	(2,1)		(1,1)	
Variables	Coefficient	t statistic	Coefficient	t statistic
α_0	0.2870** (0.1267)	2.2657	0.0499 (0.0733)	0.6807
β_0	-0.6629*** (0.2460)	-2.6951	-0.1089* (0.0578)	-1.8841
c	(-0.0070, 0.1484)		0.2092	
γ	1.9109		1.7322e+003	
RSS	5.1713		382.307	
AIC	0.2405		0.2824	

Note: For each model and each value of m, the number of transition functions r was determined by a sequential testing procedure (Table 4). For each transition function, the estimated location parameters c_j and the corresponding estimated slope parameter γ_j are reported. Coefficients differ significantly from zero at the 1%, 5%, and 10% levels, as denoted by ***, **, and * respectively.

Table 6: Relationship between the Unemployment Rate and CPI for the PSTR Models

Model A	$\pi_{it} = \mu_i + \alpha_0 \text{UNP}_{it} + (\beta_0 \text{UNP}_{it}) g(\text{IR}_{it};\gamma, c) + \varepsilon_{it}$		
Threshold Variable	*IRit*		
Regime (C)	Low Regime ($c \le -0.70\%$)	Middle Regime c = (-0.70%, 14.84%)	High Regime (c>14.84%)
UNP_{it}	-0.370	0.287	-0.370
Model B	$\pi_{it} = \mu_i + \alpha_0 \text{UNP}_{it} + (\beta_0 \text{UNP}_{it}) g(\text{GOV}_{it};\gamma, c) + \varepsilon_{it}$		
Threshold Variable	Gov_{it}		
Regime (C)	Low Regime ($c \le 20.92\%$)	Middle Regime -----	High Regime (c>20.92%)
UNP_{it}	0.0499	------	-0.059

Note: For each model and each value of , m the number of transition functions r was determined by a sequential testing procedure (Table 4). For each transition function, the estimated location parameters C_j and the corresponding estimated slope parameter r_j are reported. The coefficients differ significantly from zero at the 1%, 5%, and 10% levels, as denoted by ***, **, and *, respectively.

Figure 1 and 2 show additional information regarding the occurrence of a tradeoff relationship between the CPI and unemployment condition for monetary policy and fiscal policy. In addition, the empirical test results also indicate that the government can make effective adjustments to economic macro control, such as monitoring CPI and inflation by shifting the monetary policy and fiscal policy. The fiscal policy has a higher influence on CPI and unemployment than monetary policy if the government expenditure to GDP is higher than 20.92%.

Figure 1: Percentage Change of Interest Rate and Transition Function

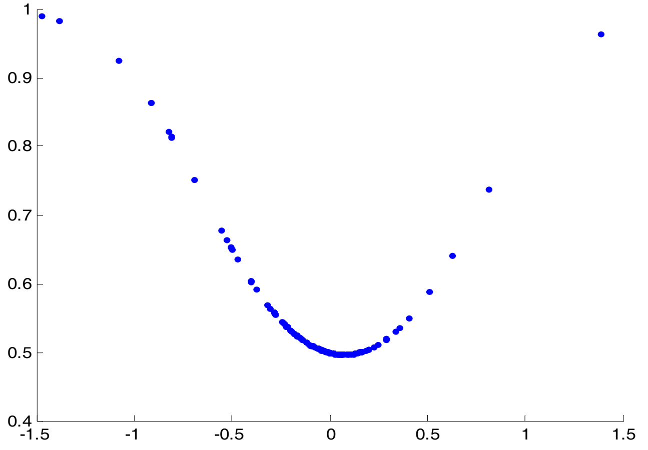
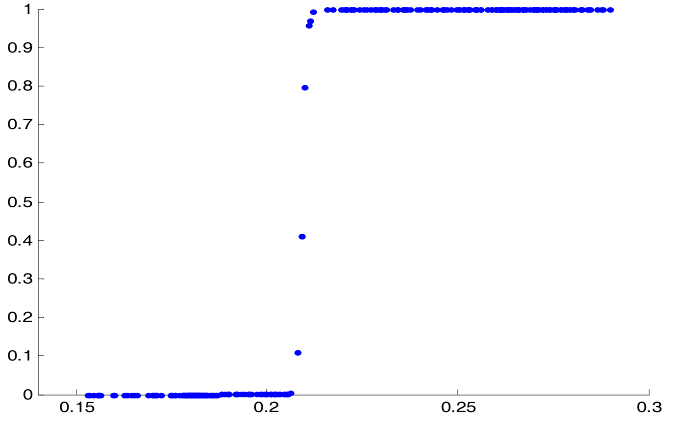


Figure 2: Ratio of Government Expenditure to GDP and Transition Function



5. Summary and Conclusion

We use the PSTR model by Gonzalez et al. (2005) to reexamine the efficiency of the Phillips curve using seven innovation-driven countries, as defined by the WEF. We focus on the period after 2000, because the economy structure has changed from a New Economy (Anderson and Kliesen, 1984 and 2001) to a New Normal[2]. We investigate the

[2] The "new normal" is a term coined by the brain trust at the giant bond fund PIMCO. Anthony

relationship between the percentage change of CPI and inflation rate based on monetary policy and fiscal policy after 2000. We use the percentage change of discount rate as a proxy for monetary policy movement, and the ratio of government expenditure to GDP as a proxy for fiscal policy.

The empirical test results show that the coefficient between CPI and inflation rate varies based on both monetary policy and fiscal policy. A further study reveals that the traditional Phillips curve does not exist when the percentage of interest rate is between -0.70% and 14.84%. Conversely, the tradeoff relationship between CPI and inflation rate remains supported when the percentage of interest rate is between -0.70% and 14.84% (the interval between lowering one basis point and raising two basis points), or when the level of government expenditure to GDP ratio is higher than 20.92%.

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Crescenzi, a PIMCO vice president, strategist and portfolio manager, is part of that brain trust. He said that it is increasingly clear that the current downturn is fundamentally different from recessions of recent decades and we are experiencing not merely another turn of the business cycle, but a restructuring of the economic order.

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