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A note on Romer's openness-inflation relation: the responsiveness of AS and AD to economic openness and monetary policy

Jim Granato[a], Melody Lo[b,*] and M. C. Sunny Wong[c]

[a]*Center for Public Policy and Department of Political Science, University of Houston, TX, USA*
[b]*College of Business, University of Texas at San Antonio, San Antonio, TX, USA*
[c]*Department of Economics, University of San Francisco, San Francisco, CA, USA*

Temple (2002) empirically challenges Romer's (1993) negative openness-inflation relation on empirical grounds. This article links economic openness to the slopes of aggregate supply (AS) and aggregate demand (AD) to explain why the openness-inflation relation can be ambiguous. Starting with a widely used assumption initiated by Romer (1993) that more open economies face greater output inflation tradeoffs, we demonstrate that greater output-inflation tradeoffs in more open economies (reflected in the steeper AS) induce policymakers to adopt more aggressive optimal monetary policy (reflected in the flatter AD). Empirical results from 15 developed countries' data support our theoretical explanation on the recent empirical failure in finding the negative openness-inflation relation.

I. Introduction

In an important paper, Romer (1993) has found that a negative economic openness-inflation relation exists. Romer argues that policymakers in more open economies have less incentive to adopt an expansionary monetary policy. He reasons that in more open economies, an unanticipated monetary expansion induces a more volatile exchange rate which, in turn, generates a larger increase in inflation for a given increase in output. In more technical language, policymakers in more open economies face a larger output-inflation tradeoff [i.e. a steeper Phillips curve or aggregate supply (AS) curve], and this reduces the propensity to engage in an expansionary monetary policy tack. Consequently, inflation rates are expected to be lower in more open economies (see also, Lane, 1997). However, Romer's argument has been challenged. For example, Bleaney (1999) and Temple (2002) found that the

*Corresponding author. E-mail: melody.lo@utsa.edu

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negative relation between economic openness and inflation is not statistically significant.

We attribute this disagreement to the interaction between AS and aggregate demand (AD). We argue that the noted negative relation by Romer (1993) and Lane (1997) is only reasonable if the level of economic openness is independent of AD. We show that policymakers do optimally respond to a higher degree of openness by adopting a more aggressive monetary policy. This policy tack produces a flatter AD slope in more open economies. Therefore, the negative economic openness-inflation relation is due to alternative factors.

More generally, the interaction and slope(s) of AS and AD has been studied intensively in the literature. This study has important implications on the effectiveness and outcome of monetary policies. For example, Kandil (1999) argues that different slopes of AS and AD would result in asymmetric volatility for both price and output when an economy faces positive and negative demand shocks. However, neither the author nor the related literature has answered a fundamental question of how the slopes of AS and AD vary in different countries. We address this issue by demonstrating that economic openness would be a potential source of the interaction and slope(s) of AS and AD. Our theoretical finding suggests there is a more complex relation between economic openness and the slopes of AS and AD. In particular, since there is a larger output-inflation tradeoff in more open economies (reflected in the steeper AS), policymakers in these economies need to adopt a more aggressive monetary policy (which creates a flatter AD) for superior economic stabilization outcomes. From our theoretical findings, we hypothesize that (1) the higher degree of openness, the steeper the AS and (2) the higher degree of openness, the flatter the AD.

We demonstrate our theory and hypotheses in Fig. 1. Figure 1 describes the inflation equilibrium controlling for the magnitude of demand shocks (or monetary policy shocks) in economies with two different levels of economic openness. In that case, we see that a positive demand shock does not necessarily create higher inflation when economic openness affects the structure of AS and AD simultaneously.

In this article, we use Romer's assumption that more open economies possess steeper AS curves, and we examine how policymakers conduct their monetary policies to optimally respond in the face of economic openness. We also re-examine if there has to be a definite negative relation between economic openness and the (equilibrium) inflation level. Using an inflation model associated with Svensson (1997), we show that in more open economies the optimal (stabilization) monetary policy rule is more aggressive in arresting inflation target deviations.

Our results, together with Romer's (1993), suggest that policymakers in more open economies are not only discouraged from adopting expansionary monetary policies, they are also motivated to act more aggressively toward inflation stability. We demonstrate further that when policymakers in more open economies adopt a more aggressive monetary policy, the slope of AD will be flatter. This result is consistent with Taylor (1994) and Romer (2000), where both studies noted that the level of aggressiveness in monetary policy is positively related to the slope of AD. We test our theory and hypotheses with a data sample consisting of 15 developed countries during the floating exchange rate period of 1973 to 2001. We find support for both hypotheses.

While several studies have found that aggressive monetary policy can reduce both inflation and output fluctuations (see Taylor, 1999, Clarida *et al.* 2000–

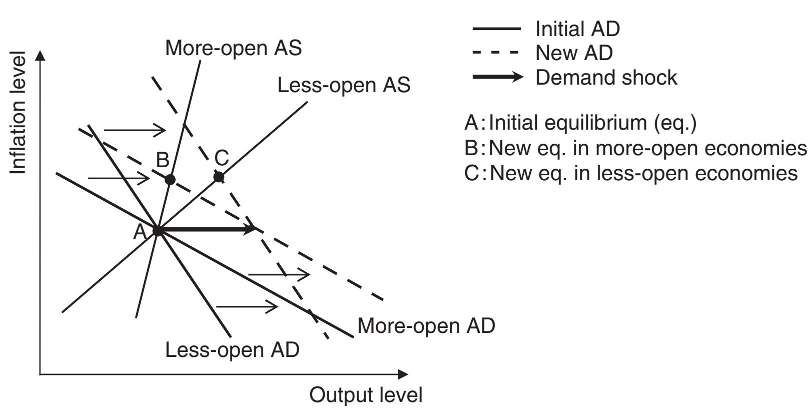

Fig. 1. The ambiguous relationship between economic openness and inflation levels

hereafter CGG, 2000). Yet, this line of research does not provide the rationale on what economic fundamentals may trigger policymakers in a country to pursue more aggressive policy than in another. We add this refinement to those findings in that we show economic openness, pertaining to the output-inflation tradeoff, is an important economic fundamental that affects a policymaker's decision regarding whether to engage in aggressive countercyclical monetary policy.

The rest of our article is organized as follows. Section II describes a modification of Svensson's (1997) inflation model. We show that the optimal monetary policy rule is more responsive (or aggressive) to inflation target deviations as the economy becomes more open. This result rests on the argument that the AD is flatter in more open economies. In Section III, we briefly detail the empirical procedures and provide estimation results on the slopes of AS and AD and their relation to the degree of economic openness. Section IV concludes the article.

II. The Model

To examine the details of the argument, we set up a simple inflation model, associated with Svensson (1997). It consists of three structural equations:

$$\pi_{t+1} - \pi_t = \alpha_w y_t + \varepsilon_{t+1}, \qquad (1)$$

$$y_{t+1} = \beta_1 y_t - \beta_2(r_t - r_{t-1}) + \eta_{t+1}, \quad \beta_1 < 1, \beta_2 > 0, \qquad (2)$$

$$m_t - p_t = y_t - \gamma i_t + v_t, \quad \gamma > 0, \qquad (3)$$

where: $\pi_t = p_t - p_{t-1}$ represents the inflation rate at time t, p_t denotes the logarithm of the price level, y_t is the logarithm of actual output relative to potential output, i_t is the nominal interest rate which is the sum of the real interest rate and inflation rate (i.e. $i_t = r_t + \pi_t$), m_t is the logarithm of monetary aggregate, and ε_t, η_t and v_t are stochastic shocks.

The coefficient α_w represents the slope of AS and according to Romer (1993) it is positively associated with the degree of openness (w) (i.e. $d\alpha_w/dw > 0$).[1] Leeper and Roush (2003) note that although recent monetary models often exclude the money stock, it is empirically inappropriate.[2] To provide a foundation for later empirical analysis, we introduce a money demand function (3) to consider the possibility that the money stock and interest rate transmit monetary policy jointly.

Consider the case where the policymaker designs an optimal interest rate policy rule to minimize the intertemporal loss function:

$$E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L(\pi_\tau, y_\tau), \quad \delta < 1,$$

and

$$L(\pi_t, y_t) = \frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda y_t^2\right]$$

Using standard techniques of dynamic programming presented in Svensson (1997), the optimal interest rate reaction function can be written:

$$i_t = b_1\pi_t + b_2(\pi_t - \pi^*) + b_3 y_t + b_4 x_t, \qquad (4)$$

where:

$$x_t = \beta_1(m_t - m_{t-1}) + \beta_1 y_{t-1} - (\beta_1\gamma - \beta_2)i_{t-1} - \beta_2\pi_{t-1},$$

$$b_1 = \frac{\beta_2 - \beta_1}{\beta_2 - \beta_1\gamma},$$

$$b_2 = \frac{1-c}{(\beta_2 - \beta_1\gamma)\alpha_w},$$

$$b_3 = \frac{1-c}{\beta_2 - \beta_1\gamma},$$

$$c = \frac{\lambda}{\lambda + \delta\alpha_w^2 k} < 1,$$

$$k = \frac{1}{2}\left\{1 - \frac{\lambda(1-\delta)}{\delta\alpha_w^2} + \sqrt{\left(1 - \frac{\lambda(1-\delta)}{\delta\alpha_w^2}\right)^2 + \frac{4\lambda}{\alpha_w^2}}\right\},$$

and $\beta_2 - \beta_1\gamma > 0$.

Equation 4 is of the form of the Taylor (1993) rule: an interest rate reaction function to the deviations of inflation from a target and to the output gap (CGG, 2000).

The coefficient of our interest, b_2, commonly viewed as an indicator for monetary aggressiveness in the policy rule literature, depends on the degree of

[1] The main objective of this article is to offer an explanation on the empirical failure of the openness-inflation relation even when Romer's (1993) assumption holds – AS is steeper in more open economies. Therefore, for the ease of analysis, we take Romer's hypothesis as an assumption such that we can directly investigate the relation between openness and both AD and AS empirically. Alternatively, one can model general equilibrium framework to allow the slope of AS to be endogenously determined. We refer interested readers to CGG (2001, 2002) as a good candidate for a general equilibrium model on the optimal monetary policy in relation to openness.

[2] Leeper and Roush (2003) empirically identify that as long as money demand is not interest inelastic, the money stock and interest rate would jointly transmit monetary policy in the US economy. Thus, ignoring the money stock in the empirical analysis would underestimate the measured effects of monetary policy on output and inflation levels.

openness (w) in an economy. We take the derivative of b_2 with respect to α_w and get $\mathrm{d}b_2/\mathrm{d}\alpha_w > 0$ for $\lambda > \alpha_w^2\delta/(1-\delta)$. We show that the parameter of the optimal interest rate policy rule that signifies the response to inflation target deviations has positive relation with the degree of openness $(\mathrm{d}b_2/\mathrm{d}\alpha_w)(\mathrm{d}\alpha_w/\mathrm{d}w) > 0$ in an economy given that policymakers are concerned about and impose enough weight on output stabilization.

This result supports the hypothesis that the monetary authorities in more-open economies are more likely to adopt more aggressive price-stabilizing monetary policies. Substituting (4) into (2) generates AD:

$$y_{t+1} = e_1(\pi_t - \pi_{t-1}) + e_2 y_t + z_{t-1} + \eta_{t+1} \tag{5}$$

where:

$$e_1 = -(1-c)/\alpha_w,$$

$$e_2 = -(1-c+\beta_1),$$

$$z_{t-1} = (1-c)y_{t-1} + \beta_1 y_{t-2} + \beta_1(m_{t-1} - m_{t-2}) - (\beta_2 - \beta_1\gamma)(i_{t-1} - i_{t-2}) + (\beta_2 - \beta_1)\pi_{t-1} - \beta_2\pi_{t-2}$$

We see that AD is flatter as the economy becomes more open (i.e. $(\mathrm{d}e_1/\mathrm{d}\alpha_w)(\mathrm{d}\alpha_w/\mathrm{d}w) > 0$).

The Taylor rule presented in (4) is different from the traditional one in that it not only considers output and inflation deviations but also money growth $(m_t - m_{t-1})$. Ireland (2001) discusses this particular version of Taylor rule. In reality, some policymakers may adopt the traditional Taylor rule. In that case, the money growth would not appear in AD.[3]

III. Empirical Evidence

Sample and data

Our particular interest is to see if policymakers adopt more aggressive monetary policy as a result of higher degree of economic openness. As researchers often acknowledge that the breakdown of the Bretton Woods system provided central banks a higher degree of flexibility in pursuing independent monetary policies, our data covers the post-Bretton Woods period (1973–2001).

We use three quarterly data from the International Monetary Fund's International Financial Statistics (IFS): Consumer Price Index (CPI), gross domestic product (GDP) and money plus quasi-money (or M2). Because quarterly GDP data are unavailable for the majority of developing countries, our analysis focuses on the group of developed countries according to IFS classification. Overall, we have 19 countries' post-Bretton Woods period data to start our empirical analysis.[4]

Model specification and estimation results

Recall that our theoretical argument that more open economies have flatter AD is based on Romer's (1993) assumption that more open economies possess a relatively steeper AS. Thus, the empirical evidence on the positive relation between openness and the slope of the Phillips (or AS) curve is a necessary condition for our theoretical argument. To assess the relation between openness and the slope of AS across countries, we estimate the following regression:

$$\mathrm{Slope}_i^{\mathrm{AS}} = \theta_1^{\mathrm{AS}} + \theta_2^{\mathrm{AS}} X_i + \varepsilon_i^{\mathrm{AS}}, \tag{6}$$

where $\mathrm{Slope}_i^{\mathrm{AS}}$ represents the slope of AS for country i, X_i, as used in Frankel and Rose (1996) and Romer (1993), is the ratio of imports of goods and services to the GDP as a measure of the degree of openness and $\varepsilon_i^{\mathrm{AS}}$ is a stochastic term.

Based on the theoretical AS Equation 1, we setup the general model of Equation 7 to estimate $\mathrm{Slope}_i^{\mathrm{AS}}$:

$$\pi_{i,t} - \pi_{i,t-1} = \mu_{i,0} + \sum_{k1=1}^{12} \omega_{i,k1}(y_{i,t-k1}) + \sum_{k2=1}^{12} v_{i,k2} \times (\pi_{i,t-k2} - \pi_{t-k2-1}) + \varepsilon_{i,t}^{\mathrm{AS}}, \tag{7}$$

where $\pi_{i,t}$ is country i's inflation rate at period t, measured by the log difference of CPI, $y_{i,t}$ is country i's output gap at period t; measured by the difference between the log value of real GDP and that of potential real GDP (which is based on the Hodrick–Prescott Filter), and $\varepsilon_{i,t}^{\mathrm{AS}}$ is a stochastic term.[5] For each country, we calculate its $\mathrm{Slope}_i^{\mathrm{AS}}$ as the sum of significant coefficients on y_t from Equation 7.

It is common knowledge that ordinary least squares estimation provides nonstandard distributional results if there is a violation of the balanced

[3] Since different countries could have different versions of Taylor rule, we make the distinction between two versions possible in our empirical analyses.

[4] These 19 countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

[5] Note that significant lags of $(\pi_{i,t} - \pi_{i,t-1})$ are included in the regression to eliminate the serial correlation, if any, in the residuals.

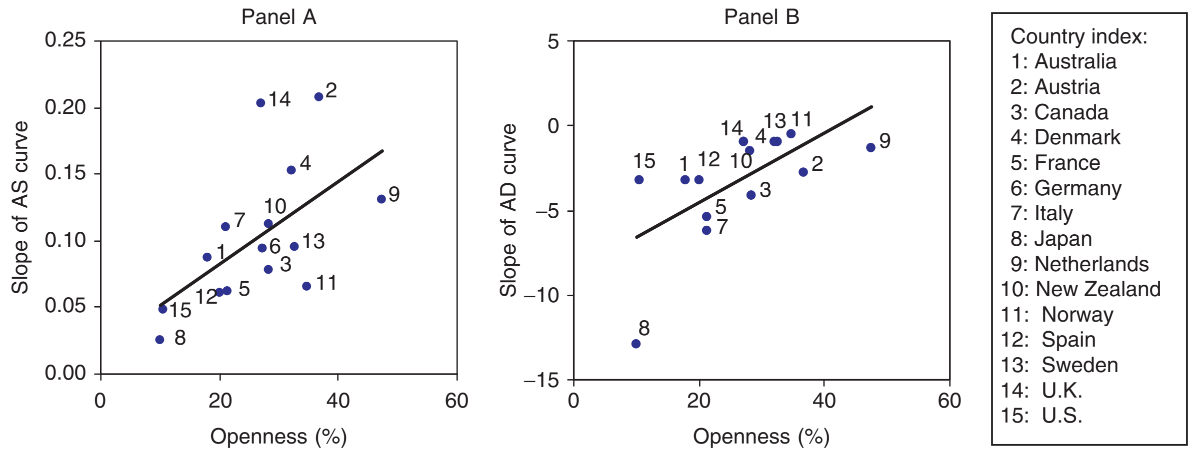

Fig. 2. Openness and slope of AS and AD curves for developed countries for 1973–2001

regression property. To avoid this violation, we use a unit root test (DF-GLS) proposed by Elliott *et al.* (1996) to examine the integration properties of the time series, $\pi_{i,t} - \pi_{i,t-1}$, and $y_{i,t}$ (which enters the Equation (7)). This test is similar to an augmented Dickey–Fuller (1979) test but has better overall power in small sample sizes. Among the 19 counties in our sample, we found there is such a violation in four cases (results are available upon request).[6] For the 15 countries left in our sample, the variables, $\pi_t - \pi_{t-1}$ and y_t, are found to be individually $I(0)$. We next proceed to search for an appropriate model to estimate $\text{Slope}_i^{\text{AS}}$ for each of these 15 countries.

In this matter, we adopt Hendry's (1995) well-known 'general-to-specific' approach to acknowledge the possibility that countries under our examination may have heterogeneous economic structures. Specifically, we apply a searching procedure detailed in Patterson (2000, Section 4.11) to search an appropriate specific model for each country based on the general model of Equation 7 which includes 12-quarter lag. The searching process begins as we test down from the general model of (7) by excluding one lag at a time in the sequence from 12 lags to 0 lags, using the t statistic (with the cut-off point being set at 95% significant level) on the marginal coefficient. For example, our first model to be estimated includes 12 lags of $y_{i,t}$. In that model, if the t-statistic on the twelfth lags falls below 95% significant level, it will be removed and we proceed to estimate the model with 11 lags. This searching process stops until we find a particular lag whose coefficient is at the 95% significant level or above. This particular lag is identified as the maximum lag to be included in the model. As suggested in Patterson (2000), we then assess if goodness-of-fit of the regression improves when insignificant lags (up to the maximum lag identified) are excluded from the regression. Overall, this searching procedure we follow provides a specific estimation model for each country with best goodness-of-fit indicated by the smallest standard error of regression and highest adjusted R-squared than any alternative model that could have been adopted. Furthermore, to ensure that the reduction in lags does not lose important information so that error from the underlying estimation model remains a mean innovation against the available information, we require that the error is free from serial correlations and ARCH up to the order of 4. The detailed estimation results for each country based on Equation 7 are available on request.

Panel A of Fig. 2 gives a scatter plot depicting the slope of the AS against economic openness for 15 countries in our sample. The figure shows an overall positive relation between the slope of AS curve and economic openness. Regression (1) of Table 1 gives the associated OLS estimation result of (6). It shows that openness coefficient is positive and significant (5% level).

As a robustness check, we first consider the possibility that openness may be endogenous and use a country's economic size (measured by total real GDP) as an instrumental variable. Regression (2) indicates that the coefficient of openness remains significantly positive. We alternatively use Cook's Distance (Cook and Weisberg, 1982) to formally identify outliers (countries Austria, Netherlands, Norway and United Kingdom in panel (A) of Fig. 2) and drop them from our sample. Regression (3) indicates that there is still a robust positive relation between openness and the slope of AS.

[6] These four countries are Belgium, Finland, Portugal and Switzerland.

With empirical support for the argument that more open economies possess a relatively steeper Phillips curve established, our next step is to examine if policymakers in more open economies respond to larger output-inflation tradeoffs (i.e. the steeper AS curve) by adopting a more aggressive monetary policy. If policymakers pursue this course of action, this would lead to a flatter AD curve. We interpret a positive relation between the slope of the AD curve and economic openness as evidence that more aggressive policy being adopted in more open economies.

To assess the relation between openness and the slope of the AD across countries, we estimate the following regression:

$$Slope_i^{\mathrm{AS}} = \theta_1^{\mathrm{AD}} + \theta_2^{\mathrm{AD}} X_i + \varepsilon_i^{\mathrm{AD}}, \qquad (8)$$

where $\mathrm{Slope}_i^{\mathrm{AD}}$ represents the slope of AD for country i, as denoted in (6) that X_i measures the degree of openness, and $\varepsilon_i^{\mathrm{AD}}$ is a stochastic term. Based on our theoretical AD Equation 5, we setup the general model to estimate $\mathrm{Slope}_i^{\mathrm{AD}}$:

$$\begin{aligned} y_{i,t} = \rho_{i,0} + \sum_{k3=1}^{12} \phi_{i,k3}(y_{i,t-k3}) + \sum_{k4=1}^{12} \varphi_{i,k4} \\ \times (\pi_{i,t-k4} - \pi_{i,t-k4-1}) \\ + \sum_{k5=1}^{12} \psi_{i,k5}(m_{i,t-k5-1} - m_{i,t-k5-2}) + \varepsilon_{i,t}^{\mathrm{AD}}, \end{aligned} \qquad (9)$$

where $\pi_{i,t}$ and $y_{i,t}$ have the same definitions as in (7), $m_{i,t}$ is country i's log value of money supply (money plus quasi money) at period t and $\varepsilon_{i,t}^{\mathrm{AD}}$ is a stochastic term. We obtain $\mathrm{Slope}_i^{\mathrm{AD}}$ by summing significant lags of $(\pi_t - \pi_{t-1})$ of Equation 9 and taking the reciprocal of it.

As mentioned earlier, there are two possible AD specifications: one with money growth and one without. Our general model of (9) allows the possibility of having money growth in the AD. To assign a correct version of AD for a country, we first estimate its AD with money growth. When money growth shows no explanatory power in that regression, the general model of (9) will reduce to an estimation model without money growth in it.

To maintain a balanced regression, we examine the degree of integration on the money growth series, $(m_t - m_{t-1})$, for each of 15 counties where we have estimated their AS. The DF-GLS test results indicate that $(m_t - m_{t-1})$ are individually $I(0)$ for each of the 15 countries (results are available upon request). Thus, we proceed to search for a specific model that has the best goodness-of-fit using the reduction method detailed earlier.

Panel B of Fig. 2 is a scatter plot depicting the slope of AD against economic openness for the 15 countries in our sample. The figure shows a positive relation between the slope of the AD and economic openness. Regression (4) of Table 1 gives the associated OLS estimation result of (8). The openness coefficient is shown to be significant (at 5% level) and positive (0.205). Regression (5) indicates that using country's economic size as an instrumental variable to re-estimate (8) still yields a significant and positive openness coefficient. In addition, when we remove outliers (countries Japan, Netherlands and United States in panel B of Fig. 2) from the sample, regression (6) shows the coefficient on openness remains significant and positive.

These results all together suggest that policymakers in more open economies act more aggressively (reflected in the flatter AD) toward economic fluctuations because they are facing a larger output-inflation tradeoffs (reflected in the steeper AS).

Table 1. Openness and the slope of AS and AD curves for developed countries for 1973–2001

	The slope of AS curve						The slope of AD curve					
Regression	(1) OLS		(2) 2SLS		(3) 2SLS (no outliers)		(4) OLS		(5) 2SLS		(6) 2SLS (no outliers)	
Constant	0.019	[0.575]	0.019	[0.689]	−0.013	[0.665]	−8.628***	[0.001]	−9.597***	[0.004]	−9.814**	[0.027]
Openness	0.003**	[0.021]	0.003*	[0.090]	0.004***	[0.008]	0.205**	[0.011]	0.241**	[0.032]	0.265*	[0.082]
LM(4)	1.252	[0.869]	1.226	[0.874]	6.631	[0.157]	3.158	[0.532]	2.960	[0.565]	1.310	[0.860]
ARCH(4)	2.863	[0.581]	2.870	[0.580]	5.100	[0.277]	1.128	[0.890]	1.913	[0.752]	1.251	[0.870]
Adjusted R^2	0.345		0.295		0.295		0.356		0.342		0.236	
Number of countries	15		15		11		15		15		12	

Notes: p-values are in brackets. ***, ** and * denotes significant level at 99%, 95% and 90% respectively in two-tailed tests. LM(4) is the Breusch–Godfrey Lagrange multiplier test statistics for serial correlation up to order 4. ARCH(4) is the ARCH test statistics up to order 4. We use Cook's Distance (Cook and Weisberg, 1982) to identify outliers and excluded them from associated regressions. For regressions (1) and (2), Austria, Netherlands, Norway and United Kingdom are outliers. For regressions (4) and (5), Japan, Netherlands and United States are outliers.

IV. Conclusions

In this article, we find support for Romer's (1993) argument concerning the relation between monetary policy and economic openness. Romer (1993) argues that more open economies produce a larger tradeoff between inflation and output thereby providing less incentive for policymakers to adopt expansionary monetary policies. The macroeconomic consequence is that there is a negative relation between economic openness and inflation.

We examine this relation by modifying Svensson's (1997) model. Our model incorporates Romer's hypothesis that more open economies face larger tradeoffs between inflation and output (a steeper AS). We show that the level of economic openness is positively related with the aggressiveness of the optimal monetary policy. More open economies not only have less incentive to implement expansionary policy, but they are also more aggressive in maintaining their inflation targets for superior economic stabilization outcomes. Furthermore, we show that policymakers in more open economies respond to inflation target deviations more aggressively and, therefore, encourage a flatter AD curve. This result offers a more complete picture of how the degree of openness affects economic structure, measured by the slopes of both the AS and the AD.

Our empirical evidence from a sample of 15 countries supports our theoretical findings. The Romer hypothesis empirically holds in the preconditional testing of the structure of AD in open economies which respond to inflation targets aggressively. We find that AD is significantly flatter in more open economies that adopts a more aggressive optimal monetary policy.

Most importantly, our findings suggest an explanation on why recent studies cannot find empirical evidence to support the negative relation between economic openness and the inflation level as suggested by Romer (1993). We argue that the lack of statistical evidence is due to the contemporaneous effect economic openness has on both AS and AD. This effect generates incomparable inflation levels among countries with different degrees of economic openness.

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