NORTH-HOLLAND

Are the Effects of Monetary Policy Asymmetric? The Case of Taiwan

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This article examines Taiwan data to determine whether or not output asymmetrically responds to monetary policy shocks. Two asymmetries are defined. For the first asymmetric effect, referred to as the TE effect, an inverted L-shaped aggregate supply curve with negative-sloped equilibrium locus is proposed. This AS curve implies that the effect of an easy monetary policy differs in different inflation regimes. The easy monetary policy is expected to have a positive effect, no effect, and a negative effect on output during low, high, and very high inflation regimes, respectively. Our results support this hypothesis. Results regarding the second asymmetric effect, referred to as RE asymmetry, are contradictory. Different classifications of recessions yield contradictory results. By employing official classification, monetary policy shocks support the RE asymmetric hypothesis. The data, however, are not overwhelmingly in favor of the RE asymmetric hypothesis using Markov switching dating. Because the dates of recessions are markedly different for the two classifications, the results demand a more in-depth probe into business cycle dating.

Key Words: Asymmetric monetary policy; Inverted L-shaped AS; Markov switching; Recessionary dating.

1. INTRODUCTION

Whether or not monetary policy asymmetrically influences real aggregate economic activity has received increasing attention. Two different asymmetric effects have been widely discussed in previous literature. The first asymmetric effect is based on the theoretical model derived by Tsiddon (1991), Caballero and Engel (1992), and Ball and Mankiw (1994), who demonstrate that, because of the sticky wage or costly price adjustment, a tight monetary policy

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has a larger absolute impact than an easy monetary policy.[1] This asymmetric effect is referred to hereafter as TE asymmetry, which claims that the effects of a tight monetary policy differ from those of an easy monetary policy. Empirical studies using U.S. data typically support this argument. Related examples include DeLong and Summers (1988), Cover (1992), Morgan (1993), Thoma (1994), Rhee and Rich (1995), and Ammer and Brunner (1995). These studies all confirm that output responds more to a tight monetary policy than to an easy policy. Hence, the sticky wage or costly price adjustment hypothesis seems credible.

The credit rationing hypothesis of Gertler (1988) implies another asymmetric effect. The reductions in credit supplies owing to recessions have little effect on large firms because large firms can raise funds directly from the money market. Rather, small firms are more financially constrained during recessions than during expansions. Hence, this second asymmetric effect, referred to hereafter as RE asymmetry, stresses that monetary policy, either tight or easy, should be more effective during recessionary than during expansionary periods of economic activity. Empirical results using U.S. data, however, are contradictory. Thoma (1994) and Garcia and Schaller's (1995) evidences support this asymmetric effect, whereas Ammer and Brunner's (1995) evidence is contrary to this effect. Thus, the credit-rationing hypothesis is supported less strongly than the sticky-price hypothesis.[2]

More recently, Karras (1996), using the panel data of 38 countries, supported TE asymmetry internationally. He employed an inverted L-shaped aggregate supply (AS) curve to account for this finding. However, using data from each country, he showed that a tight monetary policy does not necessarily exert a stronger effect on output than an easy monetary policy. Although this

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[1] In Bernanke and Gertler (1989), exogenous "technology" shocks also possibly have asymmetric effects, because negative shocks are likely to produce a greater effect than positive shocks.

[2] Studying these two asymmetries is relevant for the following three reasons. First, the results of the study are crucial for policy suggestions because they can help clarify whether a rule or a discretionary policy should be adopted. For instance, if negative shocks are more effective than positive shocks, a fixed $x\%$ rule is thus preferable to a discretionary policy (Cover, 1992). This study can also be used to determine the validity of the sticky-price and credit-rationing hypotheses. Both hypotheses are crucial to thoroughly understanding monetary policy transmissions. Finally, this study helps both theoretical and empirical researchers with respect to their model specification. If monetary policy is indeed nonlinear, an unstable linear relationship is expected to exist between money and output.

counterresult may be due to the relative few degrees of freedom when using individual country data, as explained by him, the contradictory result may also be owing to the model misspecification. Because Karras's time span covers two oil shocks, the inverted L-shaped AS may be misspecified during this very high inflation period. The first purpose of this article is to suggest a new hypothesis for the test of the TE asymmetric hypothesis. We complement the existing inverted L-shaped AS by arguing that it can be observed as a negative-sloped equilibrium locus during the very high-price regime. Figure 1 plots the conventional inverted L-shaped AS together with this negative-sloped equilibrium locus curve. The underlying argument behind this figure is that the price-adjustment behavior of economic agents possibly differs under different inflation environments. Price adjusts more quickly and more frequently during periods of high inflation than during periods of low inflation.

During the low inflation regime, such as from points A to B in Figure 1, the shifting of the aggregate demand (AD), induced by an easy monetary policy, increases output. The typical explanation for this increase is the misperception hypothesis. When the inflation rate is high and output is close to natural output, such as those from points B to C in Figure 1, workers pay sufficient attention to a price change. An outward shift of AD causes instantaneous inward shifts of AS, causing spiralling price rises but leaving output intact. Because the outcomes of these two regimes are well documented in many macroeconomic textbooks, we skip a detailed explanation here.

However, when price exceeds point C in Figure 1, as in the very high inflation regime mentioned above, households desire to hold very low real-money balances, because the opportunity cost of holding money is very high. Inventories increase, and a barter system may be revived during this regime. An increasing money supply means that a higher inflation rate not only persists in the next period but, moreover, that the authorities have no desire to curb this very high inflation. Inflation rate expectation is, thus, accelerated even more. Marginal workers may gradually withdraw from the labor market, which substantially shifts the aggregate supply inward. This inward shifting is sufficiently strong to overturn the power of the right shift of AD. Prices increase further. More importantly, output, which behaves differently from that in previous regimes, decreases in response to the increase in money supply during the very high inflation regime. A vicious circle thus

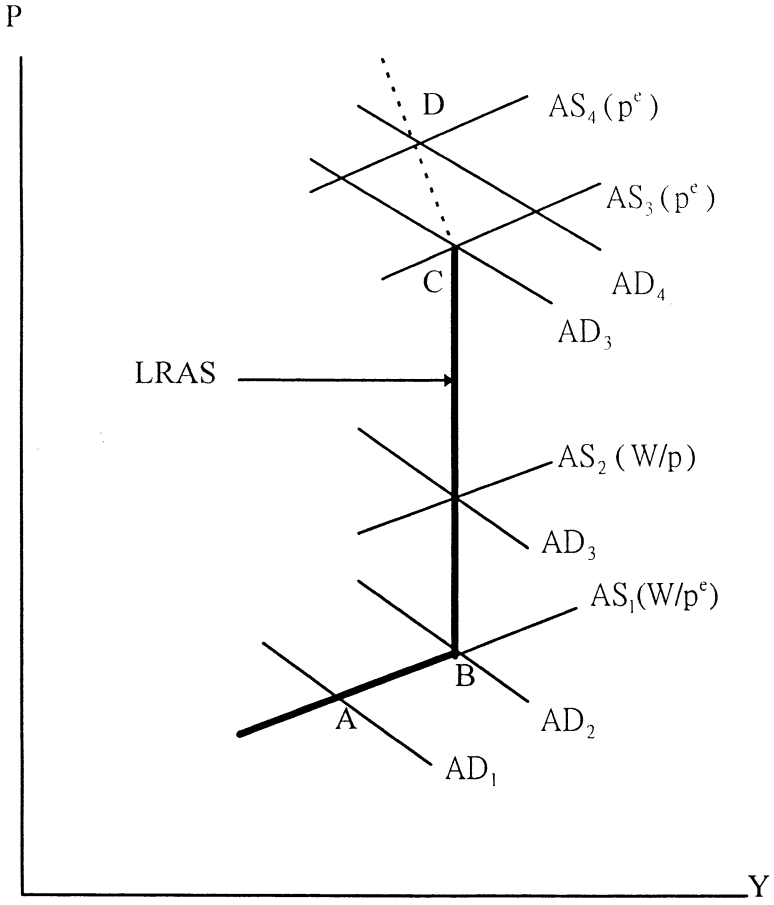

Figure 1. Inverted L-shaped AS and negative-sloped equilibrium locus. (A–B) money supply increases output; (B–C) money is neutral; and (C–D) money supply decreases output.

ensues. This implies that easy monetary policy is useful only during the low inflation regime. During the very high inflation regime, the same policy is detrimental to the economy.

The negative-sloped equilibrium locus also correlates with the hypothesis proposed by Friedman (1977), who claims that high inflation is typically associated with high uncertainty. Using an easy monetary policy at this time increases the uncertainty, and will in fact, depress, rather than increase, output growth (Holland, 1984; Shen and Chiang, 1999).

To capture this inverted L-shaped AS with negative-sloped equilibrium locus, a time-varying asymmetric model is specified. Because the influence of money policy varies with the inflation rate, the asymmetry is specified as the function of inflation.[3] Rhee and Rich (1995) have also investigated the varying asymmetric effect of monetary policy by measuring average inflation on the basis of Hamilton's (1989) Markov regime-switching model. Their results support the conventional wisdom that an easy monetary policy is futile, whereas a tight monetary policy is effective. Employing Taiwan data and using a fixed asymmetric model, we find no response in output to either an easy or a tight monetary policy. However, when considering the time-varying asymmetries, our results differ dramatically from the literature and support the plot of Figure 1.

The second purpose for testing the second asymmetric effect requires a knowledge of dates of recessions. Two classifications of recession are considered. Official datings of recessions, which are identified by the (Taiwan) Council of Economic Planning and Development (CEPD), is first employed. The second classification corresponds to Hamilton's (1989) algorithm for determining optimal recession dating based on the data. When applying U.S. data, dates of recessions and expansions should be found that are implied by the fitted model that correlates well with those determined by the NBER. Therefore, the Markov regime-switching model may be an interesting alternative to the official dating of Taiwan's business cycle. The results of testing for the RE asymmetry are mixed. No uniform answer is available regarding the effectiveness of the policy shocks during different economic conditions, because different classifications yield different dates of recessions.

The rest of this article is organized as follows. The TE and RE asymmetric hypotheses are investigated in the subsequent section and Section 3, respectively. Concluding remarks are finally made in Section 4.

2. TESTING THE TE ASYMMETRIC EFFECT OF THE MONETARY POLICY

2A. Fixed Asymmetry

Because movements in money are likely to result from the nonmonetary policy shocks as well as monetary policy shocks,

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[3] Drawing on the recent work of Ball and Mankiw (1994), the degree of asymmetry is expected to be positively associated with changes in trend (average) inflation, suggesting a time-varying degree of asymmetry.

whether or not the asymmetries identified when using monetary aggregate or discount rates can be attributed to the monetary policy per se remains unclear. To yield the true intentions of the monetary policy, the feedback movement of monetary aggregate or the discount rates to the economic activity must first be eliminated. This step requires the specification of a money supply equation.[4] The residuals are then used to identify the policy stance. Following the work of Cover (1992), Morgan (1993), and Ammer and Brunner (1995), and considering distinctive Taiwan institutional features, the money supply equation is suggested as

$$\dot{m}_t = \alpha_0 + \sum_{j=1}^{n}\alpha_{1j}\dot{m}_{t-j} + \sum_{j=1}^{n}\alpha_{2j}\dot{y}_{t-j} + \sum_{j=1}^{n}\alpha_{3j}\dot{p}_{t-j} + \sum_{j=1}^{n}\alpha_{4j}\dot{e}x_{t-j} + \epsilon_t \tag{1}$$

where $\dot{m}_t$ is the M2 money growth rate at time t, $\dot{y}_t$ is the real GDP growth rate at time t, $\dot{p}_t$ is the inflation growth rate at time t and $\dot{e}x_t$ is the real export growth rate at time t. All growth rates are annualized as $100 \times (x_t - x_{t-4})/x_{t-4}$. The source of data originates from Taiwan magnetic ARIMOS data tape.

The first three variables selected are based on the work of Ammer and Brunner (1995) to consider the systematic responses of the money supply to economic variable. The extra variable of real export growth is added because the foreign exchange earned from the export must sell to the CBC prior to 1987.[5] Hence, rapid growth of the money supply during the 1970s and 1980s primarily reflects the rapid growth of export, not the expansionary monetary polices. If this part of the responses is not excluded from the monetary instrument, we tend to overestimate the stance of the monetary policy. The lag length is selected to be 4 as the benchmark.[6]

The residual ϵ_t is employed as the proxy of monetary policy. To test for the asymmetric effect of the positive and negative policy, two additional series are created: $Tight_t = \min(\epsilon_t, 0)$, and $Easy_t = \max(\epsilon_t, 0)$.

The $Easy_t$ equals the policy proxy ϵ_t if the proxy is positive; otherwise, it equals zero. The $Tight_t$ equals the policy proxy ϵ_t if the proxy is negative; otherwise, it equals zero. Once the *Easy*

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[4] Because the discount rate in Taiwan adjusts infrequently, the money supply is used to measure monetary policy.

[5] Even after 1987, the foreign exchange earned from exports are typically sold to the CBC. Hence, exports still contribute the variation of money supply.

[6] A univariate process is herein adopted to correspond to previous literature. However, recent studies by Leeper (1992) and Gordon and Leeper (1994) suggest using multivariate processes to identify the policy shocks. This issue will be addressed in our future study.

and *Tight* are created, the output equation can be estimated by (Cover, 1992; Rhee and Rich, 1995)

$$\dot{y}_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i}\dot{y}_{t-i} + \sum_{i=1}^{n2} \beta_{2i}\dot{r}_{t-i} + \sum_{i=1}^{n3} \beta_{3i} Easy_{t-i} + \sum_{i=1}^{n4} \beta_{4i} Tight_{t-i} + e_t \qquad (2)$$

where $\dot{r}_t$ is the difference between the discount rate at time t and $t - 1$. This variable will be deleted to examine the sensitivity. The significance of coefficients β_{3i} and β_{4i} implies that the contractionary and expansionary policies influence output, respectively. More specifically, of particular concern here is the null hypothesis in which the coefficients on the $Easy_t$ are jointly equal to those on the $Tight_t$. The F-test can be used to test this hypothesis. Equations 1 and 2 are jointly estimated by a nonlinear interactive procedure suggested by Mishkin (1982). Following Mishkin (1982), the disturbances in the CBC reaction and output equations are assumed to be uncorrelated. The lag length $n1$ and $n2$ are selected to be 2, and $n3$ and $n4$ are selected to be 1 as the lowest AIC is reached. Different lag lengths of $n3$ and $n4$ are also attempted to investigate the model's sensitivity.

Table 1 summarizes the estimation results of output equation. No evidence would suggest asymmetric effects of a monetary policy shock on output. Although the findings suggest that the negative monetary policy shocks largely impact on output, the estimates do not generally associate a statistically significant effect with either type of shock. More specifically, an F-test fails to reject the null hypothesis in that the coefficients on the $Easy_t$ and $Tight_t$ are equal based on the conventional significance levels. Furthermore, the results are not sensitive to the inclusion or exclusion of discount rate terms, and also are not sensitive to the lag lengths of the policy shocks in the output equations. Thus, the data rejects fixed TE asymmetry.

Various reasons may account for this rejection. One of them is the existence of the inverted L-shaped AS with negative-sloped equilibrium locus. The policy shocks may be muted when the asymmetric effect is changing over the inflation rate, but may erroneously be assumed to be fixed. Hence, the asymmetry is not revealed when the inflation regimes are not considered.

2B. Changing Asymmetry

Although systems (1) and (2) allow for the asymmetric effects of positive and negative monetary policy shocks, the asymmetries

Table 1: Testing Fixed TE Asymmetric Effect

$$\dot{y}_t = \beta_0 + \textstyle\sum_{i=1}^{n1} \beta_{1i}\dot{y}_{t-i} + \sum_{i=0}^{n2} \beta_{2i}\dot{r}_{t-i} + \sum_{i=0}^{n3} \beta_{3i} Easy_{t-i} + \sum_{i=0}^{n4} \beta_{4i} Tight_{t-i} + e_t$$

β_0	1.746^a	2.199^a	1.980^a	2.194^a
	(3.129)	(3.762)	(3.278)	(3.550)
β_{11}	0.989^a	0.873^a	0.945^a	0.839^a
	(10.512)	(10.235)	(9.870)	(9.738)
β_{12}	−0.195^a	−0.107	−0.173^b	−0.081
	(2.039)	(1.256)	(1.813)	(0.943)
β_{20}	0.002		0.004	
	(0.572)		(1.092)	
β_{21}	−0.013^a		−0.013^a	
	(3.300)		(3.414)	
β_{30}	0.116	0.137	0.190	0.169
	(0.621)	(0.765)	(1.005)	(0.946)
β_{31}			0.117	0.219
			(0.617)	(1.228)
β_{40}	0.281	0.274	0.271	0.274
	(1.542)	(1.579)	(1.489)	(1.593)
β_{41}			0.276	0.166
			(1.446)	(0.962)
A = SUM (β_{3i})			0.307	0.388
B = SUM (β_{4i})			0.547	0.440
F-test : A = B	0.272^a	0.203	0.311	0.016
	[0.003]	[0.653]	[0.578]	[0.900]

Absolute *t*-value in parentheses.

Marginal significance level is bracketed.

^{a} and ^{b}: significant at the 10 and 5% level.

are restricted to be fixed across different inflation regimes. The inverted L-shaped AS with negative-sloped equilibrium locus, however, implies varying asymmetries, i.e., a positive relation between the degree of asymmetry and the level of trend inflation.[7] Following Rhee and Rich (1995), a trend inflation is estimated by using a three-state Markov switching model given by (see Rhee and Rich, 1995) (Eq. 3):

$$\dot{p}_t - \mu(S_t) = \sum_{i=1}^{q} \phi_i[\dot{p}_{t-i} - \mu(S_{t-i})] + \nu_t \tag{3}$$

where $\nu_t \sim i.i.d.N\ (0, \sigma_\nu^2)$, S is the unobservable state, and q is

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[7] Caballers and Engle (1992) and Ball and Mankiw (1994) also argue that asymmetry may be varying. Their model suggests that an increasing inflation trend diminishes the real effects of positive monetary policy shocks and increases the real effects of negative monetary policy shock.

selected to be 2.[8] The inflation process is modeled as a second-order autoregressive process with a three-state Markov switching process. The state-dependent means of the inflation process given by $\mu(S_t) = \mu_1 + \mu_2 S2_t + \mu_3 S3_t$ is assumed to vary across unobserved regimes that evolve according to a three-state, first-order Markov process with transition probabilities:

$$p_{ij} = P[S_t = i|S_{t-1} = j];\ i,j = 1, \ldots, 3$$

$$\sum_{i=1}^{3} p_{ij} = 1;\ j = 1, 2, 3$$

where Si_t equals a value of 1 when S_t is equal to i and 0, otherwise.

The nonlinear filter algorithm provided by Hamilton (1989, 1990) is conducted to estimate the unknown parameters. The estimation procedure yields an inference regarding the unobserved regime at time t based on the current information. The subsequent filter probabilities, $P[S_t|\dot{p}_t]$, form the basis for dating the historical incidence of the inflation regimes. The level of average inflation is thus defined based on the one-step-ahead forecast of the inflation rate according to the following formula (Eq. 4):

$$\begin{aligned}\dot{p}_{t+1}^{\mathrm{AVG}} &= E[\dot{p}_{t+1}|\dot{p}_t] \\ &= \mu_1 + \mu_2\left[\sum_{j=1}^{3} p_{2j}P[S_t = j|\dot{p}_t\right] + \mu_3\left[\sum_{j=1}^{3} p_{3j}P(S_t = j|\dot{p}_t)\right] \\ &\quad + \phi_1[\dot{p}_t - \mu_1 - \mu_2 P(S_t = 2|\dot{p}_t) - \mu_3 P(S_t = 3|\dot{p}_t) \\ &\quad + \phi_2[\dot{p}_{t-1} - \mu_1 - \mu_2 P(S_{t-1} = 2|\dot{p}_{t-1}) - \mu_3 P(S_{t-1} = 3|\dot{p}_{t-1})] \end{aligned} \tag{4}$$

The coefficients on $Easy_t$ and $Tight_t$ in Equation 2 are then specified as a linear relationship with the average inflation.

$$\beta_{3i} = d_{3i} + d_{3i}^{+} \times \dot{p}_{t-i}^{\mathrm{AVG}} \tag{5}$$

$$\beta_{4i} = d_{4i} + d_{4i}^{-} \times \dot{p}_{t-i}^{\mathrm{AVG}} \tag{6}$$

where d_{3i}, d_{4i}, d_{3i}^{+}, and d_{4i}^{-}, are unknown parameters. The coefficients d_{3i} and d_{4i} represent the "own effect" of tight and easy monetary policy shocks, respectively. The coefficients d_{3i}^{+} and d_{4i}^{-} denote the influences of interacting variables of the products of the monetary policy and the average inflation rate. If d_3 and d_3^{+} exhibit the same sign, the monetary policy is strengthened when the inflation rate

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[8] Other autoregressive lag lengths are also attempted; however, the log likelihood value is the highest when $q = 2$. The estimation results reported later are insensitive to the number of states and the autoregressive lag lengths selected here.

Table 2: Three-State Markov Switching Model for Inflation Rate

$$\dot{p}_t - \mu(S_t) = \textstyle\sum_{i=1}^{2} \phi_i[\dot{p}_{t-i} - \mu(S_{t-i})] + \nu_t$$

μ_1	35.02[a] (10.85)
μ_2	13.375[a] (2.205)
μ_3	3.3948[b] (1.805)
ϕ_1	0.800[a] (4.967)
ϕ_2	0.001 (0.290)
$\begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix}$	$\begin{bmatrix} 0.373 & 0.370 & 0.010 \\ 0.014 & 0.052 & 0.010 \\ 0.613 & 0.578 & 0.980 \end{bmatrix}$

Absolute *t*-value in parentheses.

[a] and [b]: significant at 10 and 5%.

is increased. In contrast, if they are opposite in sign, and specifically if $d_{3i} > 0$ and $d_{3i}^{+} < 0$, the effect of the expansionary monetary policy will be gradually diminished when the average inflation increases and becomes negative, and when the average inflation rate exceeds $-d_{3i}/d_{3i}^{+}$. Similar arguments hold for d_{4i} and d_{4i}^{-}.

Equation 2 is then reestimated by the nonlinear iterative method, with, however, Equations 5 and 6 being substituted into Equation 2.

Table 2 presents the average inflation based on the three-state Markov switching model. The means of three states, ranging from high, to medium, to low inflation, are 35.340, 13.566, and 3.339 percent, respectively. Panels a, b, and c of Figure 2 plot the (filter) probabilities of the inflation rate in states 1, 2, and 3 at time *t*, respectively. The first and second states coincide with the first two oil shocks, respectively. These two episodes, apart from state 3, describes the inflation rate during normal times. The transition probabilities of $p_{31} = 0.613$ and $p_{32} = 0.578$ demonstrate that once the inflation rate is in the first and second states, it tends to shift to the third state. The third state displays a high degree of persistence, with the transition probability being equal to $p_{33} = 0.980$.

The average inflation, which is then computed according to formula (4), is substituted back to (5) and (6). Equation 2 is then

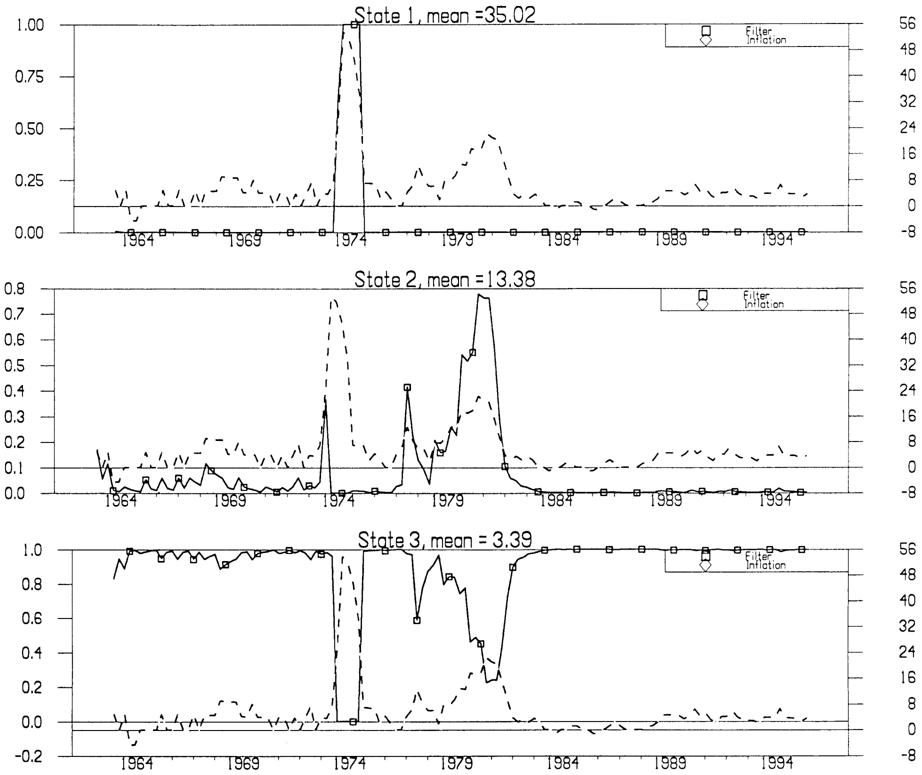

Figure 2. Filter probability of inflation rate.

Table 3: Testing TE Asymmetric Effect—Changing Asymmetry

$$\dot{y}_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i}\dot{y}_{t-i} + \sum_{i=0}^{n2} \beta_{2i}\dot{r}_{t-i} + \sum_{i=0}^{n3} \beta_{3i} Easy_{t-i} + \sum_{i=0}^{n4} \beta_{4i} Tight_{t-i} + e_t$$

$$\beta_{3i} = d_{3i} + d_{3i}^{+}\dot{p}_{t-i}^{\text{AVG}}, \ \beta_{4i} = d_{4i} + d_{4i}^{-}\dot{p}_{t-i}^{\text{AVG}}$$

β_0	2.062^a	2.451^a	2.288^a	2.427^a
	(3.765)	(4.519)	(3.590)	(4.051)
β_{11}	0.935^a	0.873^a	0.881^a	0.784^a
	(10.318)	(10.507)	(8.361)	(8.921)
β_{12}	−0.170^b	−0.128	−0.141	−0.057
	(1.873)	(1.568)	(1.489)	(0.692)
β_{20}	0.004		0.008^b	
	(1.107)		(1.824)	
β_{21}	−0.008^b		−0.009^a	
	(1.941)		(2.171)	
d_{31}	1.227^a	1.227^a	1.200^a	1.494^a
	(3.493)	(3.493)	(2.422)	(3.543)
d_{32}			−0.007	0.355
			−(0.015)	(0.882)
d_{31}^{+}	−0.088^a	−0.099^a	−0.083^b	−0.106^a
	(2.532)	(3.418)	(2.123)	(3.184)
d_{32}^{+}			0.013	−0.016
			(0.338)	(0.489)
d_{41}	−0.297	−0.227	−0.222	−0.157
	(1.027)	(0.862)	(0.703)	(0.558)
d_{42}			0.009	−0.069
			(0.026)	(0.251)
d_{41}^{-}	0.039^a	−0.037^a	(0.034)^a	0.028^b
	(2.646)	(2.501)	(1.996)	(1.702)
d_{42}^{-}				0.816
				(0.015)
A1 = SUM (d_{3i})			1.192	1.849
A2 = SUM (d_{3i}^{+})			−0.070	−0.123
B1 = SUM (d_{4i})			−0.213	−0.226
B2 = SUM (d_{4i}^{-})			0.051	0.043
F-test : A1 = B1	6.776^a	9.946^a	3.881^b	12.921^a
	[0.011]	[0.002]	[0.052]	[0.004]
F-test : A2 = B2	10.602^a	17.23^a	6.394^a	17.757^a
	[0.002]	[0.006]	[0.013]	[0.00005]
F-test : A1 = B1 and A2 = B2	5.339^a	8.633^a	3.206^a	9.155^a
	[0.006]	[0.0003]	[0.045]	[0.0002]

Absolute *t*-value in parentheses.

Marginal significance level is bracketed.

^{a} and ^{b}: significant at the 10 and 5% level.

reestimated by the nonlinear iterative method, with, however, Equations 5 and 6 being substituted into Equation 2. Table 3 summarizes the empirical findings while assuming time-varying asymmetries, with the *t*-value in parentheses. The "own effects" of the monetary policy shocks via coefficients d_{3i} and d_{4i} should be investigated, together with their corresponding inflation coefficients, d_{3i}^{+} and d_{4i}^{-}. Otherwise, misleading conclusions may be drawn.

Because coefficients $d_{31}s$ are overwhelmingly positive and significant across different lag lengths, the easy monetary policy is effective. However, the tight monetary policy, judging from coefficients β_i ($i = 1,2$), which are both insignificantly different from zero, is futile. This asymmetric effect, i.e., that the easy policy is effective and the tight policy is ineffective, goes against our intuitive interpretation at first glance. However, because it is the time-varying asymmetric model that is under consideration, the explanation of policy should be made, together with the varying inflation rate. Our effective easy monetary policy occurs, in fact, only during times of a low average inflation rate. Because the coefficient of interacted variable d_{31}^{+} is significantly negative, the effect of the easy monetary policy is thus gradually mitigated when the inflation rate is increasing. By using the values from the first column of Table 3, the easy monetary policy becomes ineffective when the average inflation is 13.94 percent (=1.227/0.088), and it becomes detrimental when the average inflation exceeds 13.94 percent.

The evidence for the gradual mitigated effective positive shock is consistent with the hypothesis proposed in Figure 1. The demand-pull effect induced by the easy monetary policy is found to have a favorable impact, no impact, and a harmful impact on output during the low, high, and very high inflation regimes, respectively. Our hypothesis is thus supported.

Panel a of Figure 3 demonstrated the changing influences of expansionary monetary policy, that is, the time varying of β_{3i}. Except for the periods covering the two oil shocks when the economy was in stagflation, the β_{3i} is above zero. This plot again suggests that the easy monetary policy is ineffective during the high inflation regime but effective during stable periods.

Although β_{4i} are insignificant, β_{4i}^{-} are significantly positive. The tight monetary policy is unfavorable to output during the high inflation period. Because both the easy and tight monetary policies are detrimental to the economy during the high inflation period, the neutral monetary authority is suggested in the stagflation situation.

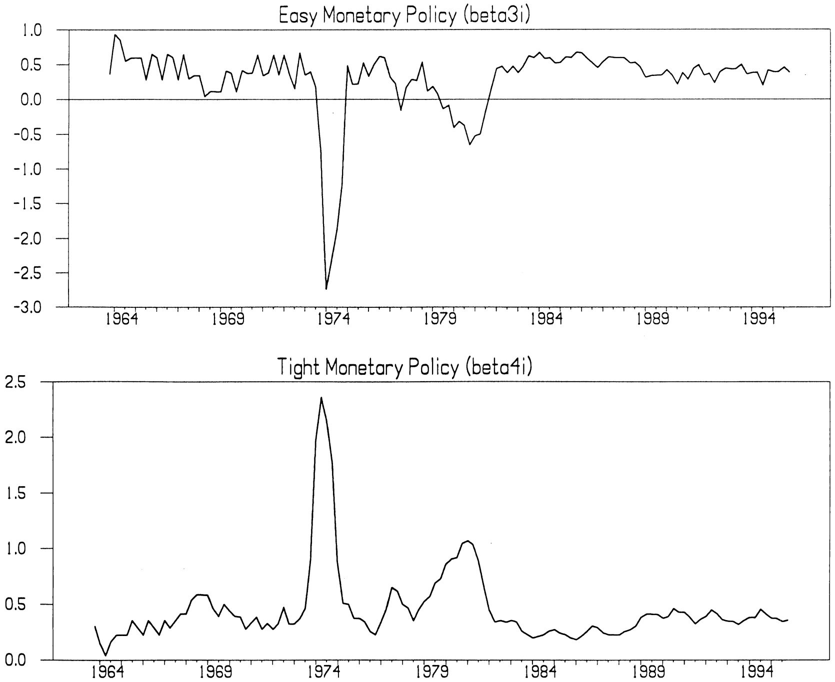

Figure 3. Changing asymmetries of monetary policy.

Panel b of Figure 3, which plots the time varying of β_{4i}, confirms the fluctuating influence of the contractionary monetary policy. The conduct of the monetary policy was not uniform across inflation episodes, reflecting the different price-adjustment behaviors of economic agents.

Columns 2, 3, and 4 of Table 3 present the sensitivity tests. The results remain unaffected when the interest rates are excluded from the model. Furthermore, neither the coefficients on lagged policy shocks and lagged crossproduce terms are significant. Thus, our results are insensitive to the inclusion/exclusion of the interest rate and the lag lengths of the policy shocks.

In summary, the results of using a varying asymmetry suggest that the fixed asymmetric model may ignore the inflation regimes pattern of the monetary policy on output. Although either the easy or tight policies are ineffective in terms of the fixed asymmetric model, they become influential when the inflation rate is considered. The effects of the easy monetary policy support our hypothesis. The tight monetary policy decreases output during high inflation periods.

3. TESTING RE ASYMMETRIC EFFECT OF THE MONETARY POLICY

Do changes in monetary policy shocks have the same sort of effects—regardless of the current state of the economy? This is the RE asymmetric hypothesis, as answered in this section. We first use an official definition of recession to explore this question. Then, Hamilton's (1989) Markov switching-regime model is extended to address this question.

3A. CEPD Recession Classification

The CEPD has identified seven recessions during the sample periods. The state variable (or dummy variable) $S_t = 0$ is used to denote the recessionary periods, and the $S_t = 1$ is the expansionary periods. Hamilton's (1989) state-autoregressive system functions as a benchmark to explore whether the output growth rate is different across two regimes. However, because the states are known in advance in this subsection, estimation procedure is easier than his Markov switching model. The benchmark model is

$$\dot{y}_t = \alpha_0 S_t + \alpha_1 + z_t \tag{7}$$

$$z_t = \phi_1 z_{t-1} + \cdots + \phi_r z_{t-r} \tag{8}$$

where the coefficients α_1 and $\alpha_0 + \alpha_1$ are the growth rates of output during recessionary and recovery periods, respectively. Both coefficients are expected to be positive. Equations 7 and 8 are simply a conventional nonlinear system, and can easily be estimated because the states are known. This benchmark model is first used by Hamilton (1989) to date recessions, which are found to coincide with that of the NBER.

The benchmark's model is then extended to consider monetary policy shocks as (Eq. 9, 10):

$$\dot{y}_t = \alpha_0 S_t + \alpha_1 + \theta_0 \epsilon_t + \theta_1 S_t \epsilon_t + z_t \tag{9}$$

$$z_t = \phi_1 z_{t-1} + \cdots + \phi_r z_{t-r} \tag{10}$$

where ϵ_t is the monetary policy shock obtained from Equation 1.[9]

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[9] The monetary policy shock and the output equation is separately estimated in this section. This procedure, although suffering from the generated regressors problem of Pagan (1984), is used for two reasons. First, the econometric technique is deeply involved in the Markov switching model if we jointly estimate the system. Second, because the interested coefficients are insignificant using nonlinear classification, the generate regressors, which increase the variances of coefficients, do not alter the conclusion.

The coefficients θ_0 can be interpreted as the effect on current output growth of a 1 percentage point increase in the monetary policy shock at time t if the economy is in a recession. The coefficients $\theta_0 + \theta_1$ have a comparable interpretation for the period when the economy is expanding. The output is symmetrically influenced by the monetary policy shock if either θ_0 or θ_1 is not equal to zero, and asymmetrically if both coefficients are not equal to zero. The model is reduced to the benchmark model when coefficients $\theta_0 = \theta_1 = 0$.

The systems (9) and (10) can be combined into the following single equation

$$\begin{aligned} \dot{y}_t = {} & \phi_1\dot{y}_{t-1} + \phi_2\dot{y}_{t-2} + \cdots + \phi_r\dot{y}_{t-r} + \alpha_1(1 - \phi_1 - \cdots - \phi_r) \\ & + \alpha_0(S_t - \phi_1 S_{t-1} - \cdots - \phi_r S_{t-r}) + \theta_1\epsilon_t \\ & - \theta_1\phi_1\epsilon_{t-1} \cdots - \theta_1\phi_r\epsilon_{t-r} + \theta_0 S_t\epsilon_t - \theta_0\phi_1 S_{t-1}\epsilon_{t-1} - \cdots - \theta_0 S_{t-r}\epsilon_{t-r} + e_t \end{aligned} \tag{11}$$

Note the estimation of Equation 11 must impose constraints on coefficients. This model is referred to as the extended I model hereafter. Garcia and Schaller (1995) relax the coefficients constraints in Equation 11 and estimate the unconstrained model as

$$\begin{aligned} \dot{y}_t = {} & \phi_1\dot{y}_{t-1} + \phi_2\dot{y}_{t-2} + \cdots + \phi_r\dot{y}_{t-r} + \alpha_1(1 - \phi_1 - \cdots - \phi_r) \\ & + \alpha_0(S_t - \phi_1 S_{t-1} - \cdots - \phi_r S_{t-r}) \\ & + \beta_{0q}\epsilon_t + \cdots + \beta_{rq}\epsilon_{t-r} + \beta_{0p}S_t\epsilon_t + \cdots + \beta_{rp}S_{t-r}\epsilon_{t-r} + e_t \end{aligned} \tag{12}$$

which is referred to as the extended II model, where $\beta_{iq} = \theta_1\phi_i$ and $\beta_{jp} = \theta_0\phi_j$, and $i,j = 1, \ldots, r$. When assessing the effectiveness of the monetary policy, one should not examine the coefficients on the monetary shocks ϵ_{t-i} and $\epsilon_{t-i}S_{t-i}$ only. Instead, the coefficients θ_0 and θ_1, though not directly observable, should be employed to assess the effectiveness. As coefficient β_{iq} (β_{jp}) is the product of $\theta_i(\theta_0)$ and ϕ_i, only when β_{iq} and β_{ip} are significant and $\phi_i s$ are insignificant, one can be sure that θ_0 and θ_1 are significant. The lag length r is selected to be 4 to yield the white-noise residuals.

Columns 1 and 2 of Table 4 summarize the results of the benchmark model with states being classified by CEPD. The coefficients $\alpha_0 = 0.790$ and $\alpha_1 = 8.337$, implying that the output growth rate is 8.337 percent at the recession and 9.127 percent at the expansion. Because α_0 is insignificantly different from zero, the two growth rates are statistically indifferent. Hence, Taiwan's output growth

Table 4: Monetary Policy Effect in Recession and in Expansion: Recessions are Dated by CEPD

$$\text{Model (B): } \dot{y}_t = \alpha_1 S_t + \alpha_0 + \theta_0 S_t \epsilon_t + \theta_1 \epsilon_t + z_t$$
$$z_t = \phi_1 z_{t-1} + \cdots + \phi_5 y_{t-r}$$

	(A) Benchmark model (CEPD date)		(B) Extended I model (CEPD date)		(C) Extended II model (CEPD date)	
Coefficient	Coeff.	*t*-Value	Coeff.	*t*-Value	Coeff.	*t*-Value
α_0	0.790	(1.308)	0.750	(1.267)	0.946	(1.628)
α_1	8.337[a]	(11.473)	8.201[a]	(11.463)	8.151[a]	(12.890)
θ_0			0.021	(0.196)		
θ_1			0.045	(0.380)		
β_{0q}					−0.107	(0.734)
β_{1q}					−0.053	(0.367)
β_{2q}					0.121	(0.884)
β_{3q}					0.401[a]	(2.750)
β_{4q}					0.387[a]	(2.510)
β_{0p}					0.372[a]	(2.238)
β_{1p}					0.157	(0.938)
β_{2p}					−0.030	(0.183)
β_{3p}					−0.306[b]	(1.788)
β_{4p}					−0.328[b]	(1.941)
ϕ_1	0.908[a]	(10.333)	0.889[a]	(10.14)	0.753[a]	(8.618)
ϕ_2	−0.056	(0.494)	−0.019	(0.172)	0.032	(0.305)
ϕ_3	0.063	(0.560)	0.065	(0.575)	0.078	(0.741)
ϕ_4	−0.351[a]	(3.229)	−0.405[a]	(3.588)	−3.343[a]	(3.271)
Log*L*	−150.413		−148.014		−137.873	
LR-test	(A) vs. (B): 0.4799 [0.028]		(B) vs. (C): 20.282 [0.002]			

Absolute *t*-value in parentheses.

Marginal significance level is bracketed.

[a] and [b]: significant at the 10 and 5% level.

rate does not adhere to two switching regimes, and can be described by only a single regime. This single-regime result is insensitive to the consideration of the monetary policy shock, as shown in columns 3 and 5.

Columns 3 and 4 of Table 4 report the estimated coefficients and their *t*-value of the extended with the constrained model (11). The monetary policy shock does not influence output asymmetrically across two states, because neither θ_0 and θ_1 are significant. The RE asymmetric hypothesis is rejected.

The estimation results of the unconstrained model (12) reported in columns 5 and 6, however, exhibit a slightly different scenario. The lagging three periods of monetary policy shocks during expansion is effective because β_{3q} is significant and ϕ_3 is not. Also, because the coefficients β_{0p}, β_{3p}, and β_{4p} are significantly different from zero, whereas only ϕ_4 is significant, the effects of monetary policy shocks are different across two states, confirming the RE asymmetric effect.

Although the three models (the benchmark and the two extended models) all support the results of single-regime output growth rate using the CEPD classification of recessions, the latter two demonstrate the conflicting evidence regarding the RE asymmetric effect. A model specification test, the likelihood ratio (LR), is then performed to assess the two models, as the constrained model is nested in the unconstrained model. The ratio is 20.82, and the marginal significant level is 0.002, rejecting the extended with the constrained model. Accordingly, the monetary shock differently affects output in two states, and the effects in recession are stronger than in expansion. Consequently, the credit-rationing hypothesis is supported.

3B. Markov Switching Recession Classification

Hamilton's (1989) switching-regime model is next employed to classify the recession from recovery because the model has proven quite successful in characterizing the nonlinear time-series properties of U.S. real output. Different from the previous subsection, the dates of recessions are unknown, and must be estimated from the data. The estimation of the first and second extended models modifies Hamilton's computed codes to allow the influence of the monetary policy shock across states.

The first two columns of Table 5 display the estimation results of the benchmark model using Hamilton's (1989) algorithm. The lag length is selected to be 4, based on the likelihood values. Different from the results in Table 4 using CEPD classification, both $\alpha_0 = 4.607$ and $\alpha_1 = 7.380$ are significant, suggesting that the output growth rate follows two switching regimes. These two coefficients decrease, but remain significant when the monetary policy shocks are added in the constrained model (reported in the third and fourth columns). The α_0 becomes insignificant in the fifth column, indicating that the output growth rate does not follow two regimes. Consequently, the benchmark and the first extended

Table 5: Monetary Policy Effect on Output in Recession and Expansion: Recessions are Dated by Markov Switching Model

$$\text{Model (B): } \dot{y}_t = \alpha_t S_t + \alpha_0 + \theta_0 S_t \epsilon_t + \theta_1 \epsilon_t + z_t$$
$$z_t = \phi_1 z_{t-1} + \cdots + \phi_5 y_{t-r}$$

	(A) Benchmark model (Hamilton date)		(B) Extended I model (Hamilton date)		(C) Extended II model (Hamilton date)	
Coefficient	Coeff.	*t*-Value	Coeff.	*t*-Value	Coeff.	*t*-Value
α_0	4.607[a]	(56.03)	2.980[a]	(3.314)	0.318	(1.043)
α_1	7.380[a]	(89.72)	4.154[a]	(2.672)	8.173[a]	(10.542)
θ_0			0.699[a]	(8.410)		
θ_1			0.036	(0.378)		
β_{0q}					0.133[b]	(1.661)
β_{1q}					0.633[a]	(3.161)
β_{2q}					−0.245	(1.307)
β_{3q}					0.076	(0.349)
β_{4q}					0.712[a]	(4.201)
β_{0p}					0.612[b]	(1.941)
β_{1p}					0.799[a]	(10.158)
β_{2p}					−0.017	(0.181)
β_{3p}					0.309[a]	(3.370)
β_{4p}					−0.383[a]	(5.603)
ϕ_1	0.999[a]	(14.08)	0.144	(1.510)	−0.506[a]	(4.460)
ϕ_2	−0.054	(0.760)	−0.336[a]	(4.488)	−0.165	(1.284)
ϕ_3	−0.141[a]	(2.020)	−0.326	(1.331)	−0.114	(0.873)
ϕ_4	−0.111	(1.592)	0.209[a]	(2.738)	0.219[a]	(2.101)
Log*L*	−147.84		−143.51		−130.02	
LR	(A) vs. (B): 8.66		(B) vs. (C): 6.982			
		[0.013]		[0.323]		
$\begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}$	$\begin{bmatrix} 0.816 & 0.080 \\ 0.184 & 0.920 \end{bmatrix}$		$\begin{bmatrix} 0.961 & 0.041 \\ 0.037 & 0.959 \end{bmatrix}$		$\begin{bmatrix} 0.886 & 0.066 \\ 0.114 & 0.934 \end{bmatrix}$	

Absolute *t*-value in parentheses.

Marginal significance level is bracketed.

[a] and [b]: significant at 10 and 5%.

models support the two-regime hypothesis of output growth, but the second extended model rejects it. Because the first extended model is nested in the second one, the *LR* test is performed. A value of 6.98 cannot reject the null hypothesis where the real output obeys the two-regime switching model.

Addressing the issue of the RE asymmetric effect, the third and the fourth columns report the estimation results of the first

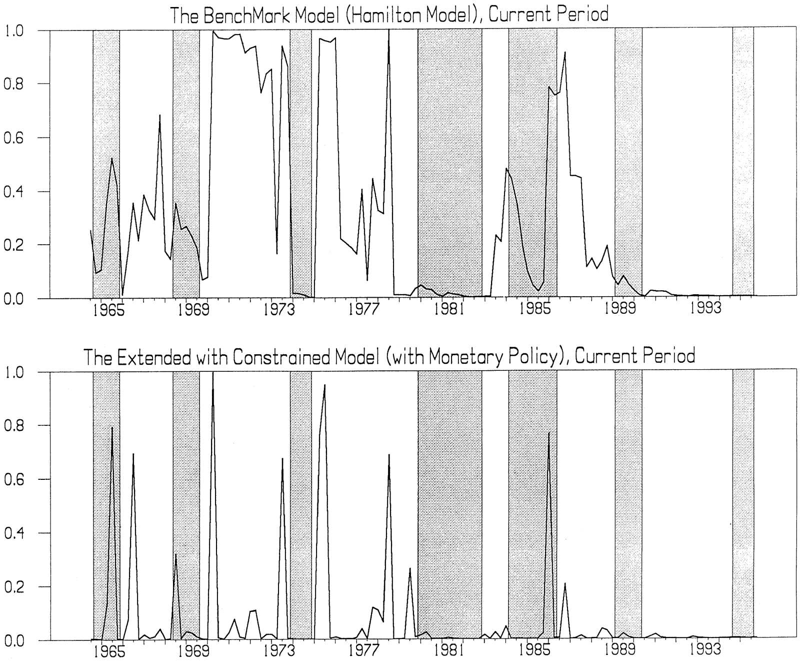

Figure 4. Filter probability of real GNP.

extended model. The monetary policy shocks are found to symmetrically affect output growth, as the coefficient θ_0 is insignificant and the coefficient θ_1 is significant. The data are, thus, not favorable to the RE asymmetric hypothesis when using the first extended model. These results are refuted when the second extended model is estimated. As columns 5 and 6 reveal, the coefficients β_{0p}, β_{1p}, β_{3p}, and β_{4p} are all significantly different from zero, whereas only ϕ_1 and ϕ_4 are significant. Because these two extended models again yield conflicting results, the *LR* test is implemented. The value of 6.98 cannot reject the null of the constrained model. The RE asymmetric effect is, thus, rejected using the Markov switching model.

Panels a and b of Figure 4 plot the filter probabilities of the first two models, respectively.[10] Unlike results discovered by using U.S. data, the recessions identified by the Hamilton's Markov

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[10] The filter probability of the third model is similar to the second model and, hence, is not plotted.

switching model, displayed in the panel a, do not match those identified by the CEPD (the shaded area). Furthermore, the filter probabilities are close to 0.5 during some periods, making the assessment of the state from the recession to expansion difficult. Because the states of the economy are substantially identified differently across two classifications, this may partially account for why results using different classifications are different. A distinction from recessionary to expansionary states are less clear in Taiwan.

4. CONCLUSION

This article examines Taiwan data to determine whether or not output asymmetrically responds to monetary policy shocks. Two asymmetries are defined. For the first asymmetric effect, referred to as the TE effect, an inverted L-shaped aggregate supply curve with negative-sloped equilibrium locus is proposed. This AS curve implies that the effect of the easy monetary policy differs in different inflation regimes. The easy monetary policy is expected to have a positive effect, no effect and a negative effect on output during low, high, and very high inflation regimes, respectively. Our results support this hypothesis.

Results regarding the second asymmetric effect, referred to as RE asymmetry, and contradictory. Different classifications of recessions yield contradictory results. By employing official classification, monetary policy shocks support the RE asymmetric hypothesis. The data, however, are not overwhelmingly in favor of the RE asymmetric hypothesis using Markov switching dating. Because the dates of recessions are markedly different for the two classifications, the results demand a more in-depth probe into business cycle dating.

REFERENCES

Ammer, J., and Brunner, A.D. (1995) International Finance Disscusion Papers. Working Paper, Board of Governors of the Ferderal Reserve Bank System.

Ball, L., and Mankiw, N.G. (1994) A Sticky-Price Manifesto. Working Paper, Federal Reserve Bank of Dallas.

Bernanke, B., and Gertler, M. (1989) Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review* 79:14–31.

Caballero, R.J., and Engel, E.M.R.A. (1992) Price Rigidities, Asymmetries, and Output Fluctuations. Technical Report, NBER, Working Paper #4091.

Cover, J.P. (1992) Asymmetric Effects of Positive and Negative Money-Supply Shocks. *The Quarterly Journal of Economics*, 1261–1282.

DeLong, J.B., and Summers, L.H. (1988) How Does Macroeconomic Policy Affect Output? *Brookings Papers on Economic Activity* 2:433–494.

Friedman, M. (1977) Nobel Lecture: Inflation and Unemployment. *Journal of Political Economy* 3:451–471.

Garcia, R., and Schaller, H. (1995) Are the Effects of Monetary Policy Asymmetric? Working Paper, Universite de Montreal.

Gertler, M. (1988) Financial Structure and Aggregate Economic Activity: An Overview. *Journal of Macroeconomics* 20:559–588.

Gordon, D.B., and Leeper, E.M. (1994) The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification. *Journal of Political Economy* 102:1228–1247.

Gordon, R.J. (1989) *Macroeconomics*, 5th ed. Boston: Scott, Foresman and Company.

Hamilton, J.D. (1989) A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle. *Journal of Econometrics* 57:357–384.

Holland, A.S. (1984) Does Higher Inflation Lead to More Uncertainty Inflation. Review, Federal Reserve Bank of St. Louis.

Leeper, E.M. (1992) Facing Up to Our Ignorance about Measuring Monetary Policy Effects. Economic Review, Federal Reserve Bank of Altanta: 1–16.

Mishkin, F.S. (1982) Monetary Policy and Short-Term Interest Rates: An Efficient Markets-Rational Expectations Approach. *Journal of Finance* 37:63–72.

Morgan, D.P. (1993) Asymmetric Effects of Monetary Policy. *Federal Reserve Bank of Kansas*, *Economic Review*, 21–33.

Pagan, A.R. (1984) Econometric issues in the Analysis of Regressions with Generated Regression. *International Economic Review* 25:221–247.

Rhee, W., and Rich, R.W. (1995) Information and the Asymmetric Effects of Money on Output Fluctuations. *Journal of Macroeconomics* 17:683–702.

Romer, C.D., and Romer, D.H. (1989) Does Monetary Policy Matter? A New Test in the Spirit of Firedman and Schwartz. In *NBER Macroeconomics Annual* (O.J. Blanchard and S. Fischer, Eds.). Cambridge, MA: MIT Press, pp. 121–183.

Shen, C.H., and Hakes, D. (1995) Monetary Policy as a Decision-Making Hierarchy The Case of Taiwan. *Journal of Macroeconomics* 17:357–368.

Shen, C.H., and Chen, H.R. (1996) Identification of Monetary Policy Indicatior in Taiwan. *Econmic Essay*, *Academic Sincia* 24:559–590.

Shen, C.H., and Chiang, T.C.N. (1999) Retrieving the Vanishing Liquidity Effect—A Threshold Vector Autoregressive Model. *Journal of Economic and Business*, forthcoming.

Thoma, A.M. (1994) Subsample Instability and Asymmetries in Money-Income Causality. *Journal of Econometrics* 64:279–306.

Tsiddon, D. (1991) The (Mis)Behavior of the Aggregate Price Level. Working Paper.