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INFLATIONARY THRESHOLD EFFECTS IN THE RELATIONSHIP BETWEEN FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH: EVIDENCE FROM TAIWAN AND JAPAN

CHIEN-CHIANG LEE AND SWEE YOONG WONG*

National Chung Hsing University and Shih Chien University

This paper employs a threshold regression model to investigate the existence of inflation threshold effects in the relationship between financial development and economic growth. A specific question that is addressed in this paper is what the threshold inflation rates are for Taiwan and Japan. Results indicate that there is one inflation threshold value in Taiwan, whereas there are two in Japan. Earlier studies support the view that financial development may promote economic growth. However, the conclusion drawn from the empirical findings suggests that it can only be achieved under low and moderate inflation. In addition, the threshold level of inflation below which financial development significantly promotes growth is estimated at 7.25% for Taiwan and 9.66% for Japan. The empirical findings from the threshold regression model indicate that inflationary threshold for both countries occurred in the high inflation period of the world energy crises in the 70s.

Keywords: Threshold Regression Model, Inflation, Financial Development, Economic Growth
JEL classification: E44, O16, C22

1. INTRODUCTION

This paper investigates the possible existence of inflationary threshold effects in the relationship between financial sector development and economic growth, using a threshold regression approach. Conventional thinking in macroeconomics holds that, in general, low inflation in conjunction with financial development is an essential element in promoting economic growth. Not surprisingly, the question of the existence and nature of the link between inflation, financial development, and economic growth has

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been the subject of considerable interest and debate. Although the debate about the precise relationship between these three variables remains open, an exhaustive literature review on this issue has produced some important empirical findings and a relatively wide consensus about some aspects of the relationship between these variables has been reached. In particular, it is generally accepted that inflation has a negative effect on medium- and long-term growth due to the influence of the former on reducing investment and productivity growth (Barro (1991); Fischer (1993); and Bullard and Keating (1995)); inflation impedes financial deepening (Bruno and Easterly (1998); Boyd *et al*. (2001)); financial development plays an important role in the growth process (Diamond and Dybvig (1983); King and Levine (1993); and Levine (1997));[1] inflation retards economic growth through its negative impact on the financial development (Azariadis and Smith (1996); Hyubens and Smith (1999)).

If inflation is a major obstacle in promoting economic growth,then it readily follows that policymakers should aim at a low rate of inflation. However, what should the target level of inflation be? How low should inflation be in order for financial development to have a positive impact on economic growth? In other words, if a non-linear relationship exists between inflation and growth, then it should be possible to estimate the threshold, or inflexion point, at which the sign of the relationship between the two variables would switches. The possibility of such a non-linear relationship was first identified by Fischer (1993), who noted the existence of a positive relationship between long-run growth and inflation at a low rate of inflation, but at higher rates it becomes negative. Following the results of Fischer (1993), there is an expanding body of evidence indicating that the relationship between inflation and long-run growth is characterized by non-linearities and the existence of thresholds (Sarel (1996); Bruno and Easterly (1998); and Singh and Kalirajan (2003)).[2]

Going beyond the empirical investigation of the non-linear relationship between inflation and growth, there are several theoretical and empirical studies focusing specifically on the existence of inflationary threshold effects in the relationship between financial development and growth. Empirical and theoretical literature nowadays suggests that financial markets play an important role in the growth process. Thus, if changes in the rate of inflation do affect activity in financial markets, then it is likely that

[1] As standard theory shows, a financial system preserves the efficiency of the payment systems, and they contribute to saving allocation. That is, a more developed financial sector leads to a better allocation of resources, better monitoring, and less information asymmetries. A comprehensive survey is provided by Levine (1997).

[2] In Sarel (1996) study, when inflation is below 8%, there is a positive correlation and vice versa. Bruno and Easterly (1998) choose the value 40% to be the breakpoint between low and high inflation regimes. Singh and Kalirajan (2003) addressed the threshold inflation rate for India, but their findings show that there is no significant structural break in the inflation-growth nexus in India. Inflation has a significant negative effect at all levels.

such changes would also have implications for long-run real activities. The studies of Hyubens and Smith (1999), Gylfason and Herbertsson (2001), Bose (2002), and Rousseau and Wachtel (2002) have demonstrated that the level of inflation is an important factor in affecting the relationship between financial development and growth. Moreover, these studies provide empirical evidence indicating that under a low or moderate inflation rate, financial development promotes economic growth. On the contrary, under higher inflation environments, financial development does not have any impact on economic growth. The reason for this is that the flow of information about investment projects and returns being used by intermediaries becomes more uncertain and less readily available in an inflationary environment. Inflation increases transactions and information costs which directly inhibit economic development. High inflation can repress financial intermediation by eroding the usefulness of money assets and by leading to policy decisions that distort the financial structure.

Taiwan and Japan have gone through different stages of development in the process of growth, however, there are some similarities between the two. International trade between both countries is closely tied, and they have experienced rapid economic growth after World War II. Banking sector plays an important role in the financial system and the process of growth in both countries. In order to continue integrating into the world economy and to enhance the ability of the financial system to match the increasing demands of industrialization and external trade, both countries lifted financial control and undergone a series of financial deregulation in the 80s. Both countries have experienced asset price boomed in the late 80s, followed by a declining in asset value in the early 90s. According to the time-series data, there was several high inflation periods occurred in the 70s and 80s in both countries. The high inflation periods in both countries can be attributed to the world energy crises in the 70s and the asset price boomed in the 80s. Although extensive empirical work has been concentrated on the nature of the relationship among inflation, financial development, and economic growth, surprisingly, the literature on this subject has largely neglected these two fast growing Asian economies. Even though only a handful of studies focus on this subject for Taiwan and Japan (Fang (1995); Sinha and Macri (2001); and Hou and Hu (2002)), the possibility of the existence of a non-linear relationship between these three variables has largely been ignored in these studies. In light of the theoretical and ad-hoc empirical literature, this paper re-examines the above issue for Taiwan and Japan with an emphasis specifically on the following questions:

1. What are the effects of financial development on economic growth under different inflation rates?
2. Is there a statistical significant threshold level of inflation above which inflation is detrimental to financial development?
3. Is there a statistically significant non-linear relationship between inflation and growth; in other words, is there a threshold level of inflation above which inflation affects growth differently than at lower inflation rates?

4. Considering the different threshold estimates obtained in the studies of Gylfason and Herbertsson (2001) and Rousseau and Wachtel (2002), are these threshold values different from those obtained in this study?[3]

These questions are examined using new econometric methods for threshold estimation and inference. The results obtained strongly support inflationary threshold effects in the relationship between financial development and growth in Taiwan and Japan. The organization of the paper is as follows. Section 2 discusses research methodology. Section 3 provides data description and empirical results followed by a concise background of Taiwan and Japan economies. Concluding remarks and policy implications are made in Section 4.

2. METHODOLOGY AND IMPLEMENTATION

There is a particular econometric issue related to the estimation and inference in models with threshold effects. Methods need to be developed to conduct empirical estimation and inference. Toward this regard, the empirical methodology used in this study is based on the threshold autoregressive (hereafter TAR) approach introduced by Tong (1978) and Hansen (1996). This model specifies that individual observations can fall into discrete classes based on the value of an observed (threshold) variable.

In growth theory, the main sources of growth power lie in the accumulation of the factor of production, and the promotion of marginal productivity and total factor productivity.[4] Based on the framework of Odedokun (1996), the production function incorporates financial development as one of the input factors given as:

$$Y_t = F(L_t, K_t, FD_t; Z_t)\,, \tag{1}$$

where Y_t denotes the real output or real GDP; L_t denotes the labor force; K_t denotes the capital stock; FD_t denotes the financial development level; Z_t denotes the other factors that affect the aggregate throughput.

After linearizing Equation (1) we obtain the following empirical equation:

$$\dot{Y}_t = \beta_0 + \beta_1 \dot{L}_t + \beta_2 \dot{K}_t + \beta_3 F\dot{D}_t + \beta_4 \dot{Z}_t + u_t\,, \tag{2}$$

[3] Gylfason and Herbertsson (2001) applied the random-effects panel model; the results show that inflation in excess of 10-20 percent per year is generally detrimental to growth. Rousseau and Wachtel (2002) employed rolling panel regressions showing that there is an inflation threshold for the finance-growth relationship that lies between 13 and 25 percent.

[4] For a detail explanation, please see Chapter Ten of Barro and Sala-i-Martin (2004).

where $\dot{Y}_t$, $\dot{L}_t$, $\dot{K}_t$, $F\dot{D}_t$, and $\dot{Z}_t$ respectively denote real GDP growth rate, labor force growth rate, investment rate, financial development index, and other factors, and u_t denotes the error term. Following the empirical framework of Beck *et al*. (2000) and Christopoulos and Tsionas (2004), we include export growth rate $(E\dot{X}_t)$ and inflation rate $(\dot{P}_t)$ to serve as the other factors that affect economic growth. Thus, the empirical regression equation can be set as:

$$\dot{Y}_t = \delta_0 + \delta_1\dot{L}_t + \delta_2\dot{K}_t + \delta_3 F\dot{D}_t + \delta_4 E\dot{X}_t + \delta_5\dot{P}_t + u_t^* . \tag{3}$$

According to the growth theory, δ_1 and δ_2 are both positive coefficients given that labor force and capital stock have a positive impact on the aggregate output. The sign and the statistical significance of the regression coefficient δ_3 measure the effects and the significant impact of financial development on economic growth. From the growth-theory literature point of view, δ_4 represents positive coefficients given that export expansion promotes economic growth. The regression coefficient δ_5 reflects the impact of inflation on economic growth. The studies of De Gregorio (1992) and Jones and Manuelli (1993) provide evidence suggesting that inflation has a significantly negative impact on economic growth. However, the study of Khan and Senhadji (2001) suggests that there is a threshold level of inflation above which inflation is detrimental to economic growth, and below this particular level, inflation is positively related to growth. Given the contradictory results found in the foregoing studies, the sign of the regression coefficient δ_5 is uncertain; therefore, it is subject to an investigation in this study.

The empirical Equation (3) represents the conventional linear growth model. However, recent literature has found that the relationship between financial development and economic growth does not follow a single pattern. For example, Huybens and Smith (1999), Gylfason and Herbertsson (2001), and Bose (2002) have found that inflation affects real variables through its impact on the financial market activities. In order to examine the effects of the interaction between inflation and financial development on economic growth, we employ the TAR model proposed by Tong (1978) and Hansen (1996). In the TAR model, the classification of the variable across regimes is based on an estimate of the time series behavior that is consistent with reaching the threshold that separates the regimes.

Consider a two-regime TAR model proposed by Hansen (1996):

$$y_t = \theta_1' x_t + e_{1t} \qquad \text{if } \; q_t \le \gamma \;, \tag{4}$$

$$y_t = \theta_2' x_t + e_{2t} \qquad \text{if } \; q_t > \gamma \,, \tag{5}$$

where q_t denotes the threshold variable, partitioning all the observed values into two groups or "regimes". Term y_t denotes the variable to be explained, whereas x_t is a matrix that, denotes the explanatory variable. The error term e_{it} is white-noise *iid*, and γ represents the threshold value, which is unknown ex ante, but can be estimated. The foregoing model shows that when the threshold variable is smaller than the threshold parameter, the regression Equation (4) is applicable. When the threshold variable is larger than the threshold parameter, the regression Equation (5) is applicable. Let $I_t(\gamma) = \{q_t \leq \gamma\}$, and $\{\bullet\}$ as an indicator function with $I = 1$ if $q_t \leq \gamma$ occurs, or $I = 0$ otherwise. Moreover, when we let $x_t(\gamma) = x_t I_t(\gamma)$, then Equations (4) and (5) can be revised as follows:

$$y_t = \theta' x_t + \rho' x_t(\gamma) + e_t, \qquad e_t \sim iid(0, \sigma_t^2). \tag{6}$$

Therein, $\theta = \theta_2$, $\rho = \theta_1 - \theta_2$, $e_t = [e_{1t}\ e_{2t}]'$, and θ, ρ, and γ are the parameters to be estimated.

Equation (6) allows all the regression coefficients to differ between sample groups. The resulting sum of squared error as a result of estimating these parameters θ, ρ, and γ can be expressed as follows:

$$S_1(\gamma) = \hat{e}_t(\gamma)' \hat{e}_t(\gamma). \tag{7}$$

Hansen (1996) recommended an estimation of γ by the least-squares method. This can be achieved by minimizing the sum of squared errors in (7). Hence, the optimum threshold value is given as:

$$\hat{\gamma} = \arg\min S_1(\gamma), \tag{8}$$

and the variance of the residual is expressed as:

$$\hat{\sigma}^2 = \frac{1}{T} \hat{e}_t \hat{e}_t = \frac{1}{T} S_1(\hat{\gamma}). \tag{9}$$

Once $\hat{\gamma}$ is obtained, the vectors of the slope coefficient estimated are $\hat{\theta} = \hat{\theta}(\hat{\gamma})$ and $\hat{\rho} = \hat{\rho}(\hat{\gamma})$. According to the foregoing process, the regression Equation (3) under a two-regime TAR model can be expressed as:

$$\begin{aligned} \dot{Y}_t = {} & (\delta_{10} + \delta_{11}\dot{L}_t + \delta_{12}\dot{K}_t + \delta_{13}F\dot{D}_t + \delta_{14}E\dot{X}_t + \delta_{15}\dot{P}_t) I[q_t \leq \gamma] \\ & + (\delta_{20} + \delta_{21}\dot{L}_t + \delta_{22}\dot{K}_t + \delta_{23}F\dot{D}_t + \delta_{24}E\dot{X}_t + \delta_{25}\dot{P}_t) I[q_t > \gamma] + e_t^*. \end{aligned} \tag{10}$$

In the estimation of model (10), the threshold value is determined by obtaining the threshold value that minimizes the sum of the squared error given by Equation (7). Since the purpose of this paper is to investigate the inflationary threshold effects in the relationship between financial development and economic growth, the annual growth rate of inflation is employed as the main threshold variable in the analysis. Before applying the two-regime TAR model such as (10), we need to test for the threshold effects. In this case, it is analogous to testing the null hypothesis of the linear model against the alternative hypothesis of the two-regime model such as equation (10).

Conventional methods of hypothesis testing cannot be applied, because of the difficulty with the threshold parameter γ being unidentified under the null hypothesis. In this case, the underlying distribution of a large sample is not distributed by Chi-square distribution. Hansen (2000) proposed a solution for this particular problem and suggested that relevant tests be conducted through the use of a Lagrange Multiplier (*LM*) bootstrap procedure. Since γ is not identified under the null hypothesis of the no-threshold effect, the *p*-values are computed by a fixed bootstrap method.

To examine by testing whether the coefficients in the two regimes are the same or not, the null hypothesis of no threshold effect to Equation (10) is:

$$H_0 : \delta_{1i} = \delta_{2i} \qquad i = 0...5 . \tag{11}$$

Let S_0 and S_1 be the residual sum of squares under the null hypothesis and alternative of (11). As such, the F -test is based on:

$$F_1 = \frac{S_0 - S_1(\hat{\gamma})}{\hat{\sigma}^2} . \tag{12}$$

Once the threshold effect exists, the next question is whether or not the threshold value can be known. The null hypothesis of the threshold value is $H_0 : \gamma = \gamma_0$, and the likelihood ratio statistics is:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\hat{\sigma}^2} , \tag{13}$$

where $S_1(\gamma)$ and $S_1(\hat{\gamma})$ are the residual sum of squares from Equation (7) given the true and estimated value, respectively. The asymptotic distribution of $LR_1(\gamma_0)$ can be used to form valid asymptotic confidence interval about the estimated threshold values. The statistics of $LR_1(\gamma_0)$ are not normally distributed and Hansen（2000）computed their no-rejection region, $c(\alpha)$, α is a given asymptotic level.[5] That is, if $LR_1(\gamma_0) \le c(\alpha)$, where $c(\alpha) = -2\ln(1-\sqrt{1-\alpha})$, then the null hypothesis of $H_0 : \gamma = \gamma_0$ cannot be rejected.[6]

Aside from testing the existence of one threshold value, to further investigate whether there are two or more threshold values that exist, we first employ the F_1 test to assess the null hypothesis of no threshold. If this null hypothesis is rejected, then at least one threshold value is ensured. We next proceed to test the null of one threshold against the two thresholds. We assume a known estimated $\hat{\gamma}_1$ and proceed to search the second threshold, γ_2. In this case, we obtain the following:

$$S_2^r(\gamma_2) = \begin{cases} S(\hat{\gamma}_1, \gamma_2) & \text{if } \hat{\gamma}_1 < \gamma_2 \\ S(\gamma_2, \hat{\gamma}_1) & \text{if } \gamma_2 < \hat{\gamma}_1 . \end{cases} \tag{14}$$

The threshold value, the null hypothesis, and the F-test are respectively stated as follows:

$$\hat{\gamma}_2^r = \arg\min S_2^r(\gamma_2) , \tag{15}$$

$$H_0 : \text{only one threshold}, \tag{16}$$

$$F_2 = \frac{S_1(\hat{\gamma}_1) - S_2^r(\hat{\gamma}_2^r)}{\hat{\sigma}_2^2} , \tag{17}$$

where $S_1(\hat{\gamma}_1)$ is referred to as the sum of squared errors acquired from the previous threshold estimation. The residual variance is given as follows:

$$\hat{\sigma}_2^2 = \frac{1}{T} S_2^r(\hat{\gamma}_2^r) . \tag{18}$$

The significant F_2 implies the rejection of the null of one threshold and two thresholds are expected. If two thresholds cannot be rejected, than the confidence interval for two thresholds (γ_1, γ_2) can be constructed in the same way. The procedures are carried out until the null in (11) can no longer be rejected.

[5] The no-rejection region of the confidence level is $(1-\alpha)$.

[6] Equations (13) and (12) are different, and $LR_1(\gamma)$ tests if the threshold estimator $\hat{\gamma}$ is equal to actual threshold regime γ_0, and the F distribution tests if the coefficients of the two regimes are equal or not.

3. THE EMPIRICAL RESULTS

3.1. The Description of the Data Set and Variables

The principle data source of Taiwan in this paper is taken from the AREMOS economic statistics database, which is a public database compiled by the Ministry of Education, Taiwan, R.O.C. Japan's data all emanate from IMF's *International Financial Statistics.* The dataset for Taiwan starts from the first quarter of 1965 to the last quarter of 2002 with 2001 serving as the base year for the Consumer Price Index (CPI). The dataset for Japan starts from the first quarter of 1970 to the last quarter of 2001 with 1995 as the base year for CPI. The description of the variables is as follows:

$\dot{Y}$ = The economic growth rate represented by the annual growth rate of gross domestic product (GDP).

$\dot{L}$ = The population growth rate has been used as the proxy for labor force growth which represented by the annual growth rate of total population.

$\dot{K}$ = Real investment variable represented by the annual growth rate of real gross domestic fixed capital formation.

$F\dot{D}$ = Financial development variable represented by the annual growth rate of real liquid liabilities of the financial sector (currency plus demand and interest-bearing liabilities of banks and non-bank financial intermediaries) as the index for financial depth according to Odedokun (1996).[7]

$E\dot{X}$ = Real export variable represented by the annual growth rate of real commodities and services export. The inclusion of this variable is to measure the degree of trade openness. Moreover, given the fact that Taiwan's economy is export-oriented, its performance in trade has a profound impact on the domestic economy.

$\dot{P}$ = Inflation variable represented by the annual growth rate of CPI.

Table 1 reports some descriptive statistics of the six key variables. Taiwan and Japan have the highest inflation of 61.4% and 23.4%, respectively, whereas Taiwan's average inflation is 5.1%, and Japan is only around 3.8%. Table 2 presents the correlation matrix of explanatory variables for Taiwan. As can be seen, the highest correlation is 0.652 between the inflation rate and finance development indicator and the lowest correlation is 0.012 between the inflation rate and investment rate. The remaining correlation coefficients are around -0.246 to 0.402, which are acceptable to avoid the multi-collinearity problem. Table 3 presents the correlation matrix of explanatory variables for Japan, where the highest correlation is 0.590 between the investment rate

[7] This indicator measures the overall size of the formal financial intermediary sector, and has been found to be very strongly associated with both the level and economic growth rate.

and finance development indicator and the lowest correlation is -0.015 between the inflation rate and population growth. The remaining correlation coefficients are around -0.222 to 0.455, which are acceptable to avoid the multi-collinearity problem.

Table 1. Summary Statistics of Variables

Variables	Mean	Std. Dev.	Max.	Min.	Skewness	Kurtosis
Taiwan						
$\dot{Y}$	0.077	0.057	0.217	-0.140	-0.434	4.423
$\dot{L}$	0.015	0.008	0.050	0.005	1.407	5.933
$\dot{K}$	0.083	0.117	0.386	-0.313	-0.086	3.655
$F\dot{D}$	0.142	0.098	0.404	-0.231	-0.697	4.993
$E\dot{X}$	0.116	0.151	0.603	-0.298	0.518	3.539
$\dot{P}$	0.051	0.008	0.614	-0.016	4.006	21.830
Japan						
$\dot{Y}$	0.026	0.030	0.121	-0.046	0.383	3.651
$\dot{L}$	-0.005	0.018	0.027	-0.071	-0.442	3.423
$\dot{K}$	0.017	0.061	0.162	-0.139	0.387	2.797
$F\dot{D}$	0.051	0.054	0.189	-0.121	-0.518	5.230
$E\dot{X}$	0.032	0.108	0.403	-0.187	0.670	4.243
$\dot{P}$	0.038	0.049	0.234	-0.010	2.167	8.294

Table 2. Correlation Matrix: Taiwan

	$\dot{L}$	$\dot{K}$	$F\dot{D}$	$E\dot{X}$	$\dot{P}$
$\dot{L}$	1				
$\dot{K}$	0.296	1			
$F\dot{D}$	0.150	0.231	1		
$E\dot{X}$	0.402	0.391	0.426	1	
$\dot{P}$	0.188	0.012	0.652	-0.246	1

Table 3. Correlation Matrix: Japan

	$\dot{L}$	$\dot{K}$	$F\dot{D}$	$E\dot{X}$	$\dot{P}$
$\dot{L}$	1				
$\dot{K}$	0.359	1			
$F\dot{D}$	0.090	0.590	1		
$E\dot{X}$	0.278	-0.038	-0.222	1	
$\dot{P}$	-0.015	-0.136	-0.138	0.455	1

3.2. Test for the Existence of Inflationary Threshold Effects

The Phillips and Perron (PP; see Phillips and Perron (1988)) test is employed to examine the hypothesis of a unit root among the variables. The results of Taiwan and Japan are presented in Table 4. In each case, the number of lags is chosen such that no serial autocorrelation in residuals is evident in the auxiliary regressions. The results of the test show that the null hypothesis of unit root is rejected at the 5% level of significance in drift term or drift term and time trend, which implies that the underlying variables for Taiwan and Japan show a stationary process.

Table 4. Results of Unit Root Tests

Country	Taiwan	
Variable	Drift term	Drift term and time trend
$\dot{Y}$	-4.461**	-4.986**
$\dot{L}$	-1.986	-3.814**
$\dot{K}$	-4.612**	-5.255**
$F\dot{D}$	-4.079**	-4.275**
$E\dot{X}$	-5.554**	-6.162**
$\dot{P}$	-4.058**	-4.313**
Country	Japan	
Variable	Drift term	Drift term and time trend
$\dot{Y}$	-3.516**	-3.958**
$\dot{L}$	-2.883**	-2.888
$\dot{K}$	-3.252**	-3.458**
$F\dot{D}$	-3.265**	-3.601**
$E\dot{X}$	-4.124**	-4.199**
$\dot{P}$	-1.993	-5.319**

Notes: The 5% critical values with time trend estimation and without time trend estimation are respectively -3.440 and -2.881. The critical values are from Mackinnon (1991). "**" indicates that at the 5% level of significance.

Before applying the TAR model such as Equation (10) to investigate the impact of the financial development on economic growth under different inflation regimes in Taiwan and Japan, we proceed to test for the threshold effects with the annual growth rate of inflation serving as the threshold variable. In this case, it simply amounts to testing the null hypothesis of the linear model against the alternative hypothesis of the two-regime model. Because of the threshold parameter γ being unidentified under the null hypothesis, conventional tests (such as the *t*-test) have non-standard distributions. Hansen (1996) proposed a bootstrap method to stimulate the asymptotic distribution of the likelihood ratio test of the null hypothesis. The results of the threshold test and the asymptotic *p*-values obtained through 1,000 bootstrap replications are reported in Table 5 and Table 6 for Taiwan and Japan, respectively.

Table 5. Test Results of Inflation Threshold Effect and Threshold Estimates for Taiwan

Null of hypothesis	*F* test	Bootstrap *p*-value	Estimate threshold
Null of no threshold	16.263**	0.029	$\hat{\gamma}_1 = 7.2526\%$
Null of one threshold	12.452	0.182	

Notes: Estimation period is 1965Q1 to 2002Q4. Threshold variable is denoted as $\dot{p}$. The thresholds are obtained by the minimum sum of the squared residual. The *F* test is calculated based on (13). "**" is significant for 5%.

Table 6. Test Results of Inflation and Threshold Effect Threshold Estimates for Japan

Null of hypothesis	*F* test	Bootstrap *p*-value	Estimate threshold
Null of no threshold	26.046**	0.000	$\hat{\gamma}_1^r = 2.5278\%$
Null of one threshold	18.155**	0.001	
Null of two thresholds	9.196	0.637	$\hat{\gamma}_2^r = 9.6658\%$

Notes: Estimation period is 1970Q1 to 2001Q4. Threshold variable is denoted as $\dot{P}$. The thresholds are obtained by the minimum sum of the squared residual. The *F* test is calculated based on (13). "**" is significant for 5%.

The threshold effect is first examined. We employ the *F*- test to examine the equality of coefficients in the two regimes, and the *LR* test examines the equality of potential threshold values. Table 5 reports the testing results and the bootstrapped *p*-values for Taiwan. The statistics of F_1 is 16.263 for specification (10), as F_1 exceeds the critical values at the 5% significant level, suggesting one threshold at least. Then we proceed to investigate the possibility of the existence of more than one threshold, and the test results cannot reject the one threshold's null hypothesis. This implies that one inflation threshold value exists for Taiwan, which is 7.2526%. As a result, the data on the growth rate of inflation for Taiwan can be divided into low and high inflation regimes.

The estimation results are quite similar to the results reported in the studies of Sarel (1996) and Khan and Senhadji (2001). Sarel (1996) investigated the non-linear relationship between inflation and economic growth. A panel data analysis was employed to analyze a sample of 87 countries covering the period from 1970 to 1990. The result showed that there was a remarkable structural threshold value between inflation and economic growth; the threshold value was 8%. Khan and Senhadji (2001) provided evidence to suggest that the inflation threshold value for industrial countries was in between 1% to 3%; in the case of developing countries, it was in-between 7% to

11%. Once the thresholds are obtained, the next step is computing the *LR* test to examine their respective confidence interval. The 95% asymptotic confidence interval as [7.05%, 7.60%]. This extremely tight confidence interval suggests that the threshold estimates are very precise. Hence, there is strong evidence supporting one threshold in the regression relationship. Compared with this study, both of the previous studies did not investigate the impact of the relationship between inflation and financial development on economic growth. In addition, these studies employed pooled cross sectional time-series data, whereas this study considers each country individually by employing time-series data.

Table 6 reports that the statistics F_1 and F_2 exceed the bootstrapped critical values at the 5% significant level for Japan, suggesting the possibility of two thresholds, which are 2.5278% and 9.6658%. Consequently, the data on the growth rate of inflation for Japan can be divided into low, moderate, and high inflation regimes. We compute the *LR* test mentioned above, and the 95% confidence interval as [2.44%, 2.73%] and [8.12%, 9.96%] for the above two thresholds, respectively.

3.3. Inflation, Financial Development, and Economic Growth

Once the search for the inflation threshold effects is conducted for Taiwan and Japan, we proceed to investigate the relationship between inflation, financial development, and economic growth under different inflationary regimes for both countries.

Table 7. The Estimation Results of the Inflation Financial Development and Economic Growth for Taiwan

Explanatory Variables	Linear model	Low inflation rate	High inflation rate
Threshold Value		$\leq 7.2526\%$	$> 7.2526\%$
Constant	0.018	0.011	0.052
	(2.800)**	(1.874)*	(0.673)
$\dot{L}$	-0.185	-0.342	0.158
	(-0.379)	(-0.663)	(0.042)
$\dot{K}$	0.102	0.105	0.070
	(5.175)**	(4.816)**	(1.708)*
$F\dot{D}$	0.237	0.297	0.039
	(5.861)**	(7.115)**	(0.642)
$E\dot{X}$	0.188	0.160	0.351
	(7.234)**	(5.902)**	(8.385)**
$\dot{P}$	-0.040	-0.012	-0.191
	(-0.912)	(-0.186)	(-3.413)**
R^2	0.779	0.765	0.898
Numbers of Sample	148	124	24

Notes: Estimation period is 1965Q1 to 2002Q4. Threshold variable is $\dot{P}$. "**" and "*" respectively represent 5% and 10% levels of significance. Values in parentheses are *t* values.

Table 7 summarizes the estimation results of the relationship between these three variables for Taiwan. For comparison purposes, the first column displays estimates for a linear specification that ignores the threshold effect. The remaining columns provide estimates of the TAR model. The results of the first column indicate that financial development is an important ingredient in promoting Taiwan's economic growth, as the significant coefficient is 0.237. Table 7 shows that when the annual growth rate of inflation is below 7.2526%, financial development has a significant effect on economic growth in Taiwan, where the coefficient is 0.297. However, when inflation is above this threshold value, financial development does not have any significant impact on economic growth. As a result, financial development that promotes economic growth can only be established under low inflation. This empirical finding is consistent with the conclusion derived from the theoretical models of Huybens and Smith (1999), and Bose (2002). Note that both investment and export variables have a positive and significant impact on economic growth regardless of the inflation regimes. This finding reinforces the fact that Taiwan's economy indeed heavily depends on trade.

Table 8. The Estimation Results of the Inflation Financial Development and Economic Growth for Japan

Explanatory Variables	Linear model	Low inflation rate	Moderate inflation rate	High inflation rate
Threshold Values		≤ 2.5278%	2.5278% ~ 9.6658%	≥ 9.6658%
Constant	0.009 (4.198)**	0.018 (6.838)**	-0.002 (-3.532)**	0.208 (2.390)**
$\dot{L}$	0.199 (3.283)**	0.693 (7.634)**	0.222 (1.844)*	0.630 (0.932)
$\dot{K}$	0.278 (11.393)**	0.254 (10.477)**	0.326 (7.705)**	0.226 (1.826)*
$F\dot{D}$	0.232 (6.112)**	0.136 (3.605)**	0.262 (5.530)**	-0.174 (-0.839)
$E\dot{X}$	-0.011 (-0.875)	0.015 (1.132)	-0.067 (-4.102)**	0.146 (5.482)**
$\dot{P}$	0.030 (0.776)	-0.219 (-1.452)	0.258 (2.997)**	-1.192 (-2.836)**
R^2	0.847	0.906	0.847	0.981
Numbers of Sample	124	67	46	11

Notes: Estimation period is 1970Q1 to 2001Q4. Threshold Variable is $\dot{P}$. "**" and "*" respectively represent 5% and 10% levels of significance. Values in parentheses are *t* values.

Table 8 summarizes the estimation results of the relationship between inflation, financial development, and economic growth for Japan. The empirical results obtained from the estimation of the linear model show that financial development is an important ingredient in promoting Japan's economic growth, as the significant coefficient is 0.232. The non-linear estimation produces results suggesting that under a low (lower than 2.5278%) or moderate (between 2.5278% and 9.6658%) inflation rate, financial development has a significantly positive impact on economic growth. However, under a high inflation regime (inflation rate higher than 9.6658%), financial development is unrelated to economic growth. Due to the result, the conclusion that financial development may promote economic growth can be established only when Japan's inflation rate is low or moderate.

3.4. The Relationship Between Inflation and Economic Growth

Table 7 also provides empirical evidence that in Taiwan, inflation has no significant negative impact on economic growth in linear estimations. However, under a high inflation regime (inflation above the threshold value of 7.2526%), inflation is detrimental to economic growth, as the significant coefficient is -0.191. In the case of Japan, the results summarized in Table 8 indicate that under a moderate inflation regime (inflation rate in between 2.5278% and 9.6658%), inflation promotes economic growth, where the significant coefficient is 0.258. However, when inflation is higher than 9.6658%, inflation has a significant negative effect on economic growth, as the coefficient is -1.192. The foregoing estimated non-linear relationship between inflation and economic growth is consistent with the empirical and theoretical conclusion derived in the studies of Sarel (1996), and Bose (2002); that is, high inflation has a negative effect on economic growth. This paper addresses what the threshold inflation rates are for Taiwan and Japan.

3.5. Inflationary Thresholds and the Economies of Taiwan and Japan

After World War II, Taiwan and Japan achieved remarkable record of high and sustained growth, often in the context of activist public policies. Between 1960 and1985, real income per capita increased more than four times in Japan and Taiwan, and more than double in the Southeast Asian Newly Industrialized Nations (NIEs).[8] The spectacular economic performance in Taiwan is attributable to a series of growth-enhancing public policy with low inflation and macroeconomic stability as a framework, and the development and liberalization of the financial system. Figure 1 summarizes the economic performance, inflation, and the financial development in

[8] See Figure 2, page 3 of The East Asian Miracle: Economic Growth and Public Policy, A World Bank Policy Research Report, 1993.

Taiwan over the sample period. It shows that economic growth in Taiwan is highly correlated with its financial development. The development policy of Taiwan has consisted of five stages in which the government has implemented comprehensively. Namely, they are Land Reform and Reconstruction (1949-52), Import-Substituting Industrialization (1953-57), Export Promotion (1958-72), Industrial Consolidation and New Export Growth (1973-80), and High Technology and Modernization (1981-).[9] The financial system in Taiwan has often been criticized as being underdeveloped and inefficient, particularly, the financial system's inability to match the increasing demands of industrialization and external trade. The financial system in Taiwan was even regarded as a major obstacle to further economic growth in the 80s. As a result, the government launches a series of financial liberalization (which include deregulation and internationalization) during 1980s.[10] In the late 1980s and early 1990s, stock and real estate markets boomed, and the economy experienced the so-call "bubble economy".

Figures 1 and 2 provide further evidence to suggest that in the process of economic growth, high inflation period of the 70s resulting from the world energy crises has a profound impact on the financial development and economic growth for both countries. The empirical findings from the TAR analysis indicate that inflationary thresholds for both countries occurred in the high inflation period of the 70s. In the case of Taiwan, inflationary threshold value of 7.25% occurring in the third quarter of 1970. As for Japan, it's inflationary threshold value is 9.66%, occurring in the third quarter of 1976. The shaded areas in Figures 1 and 2 represent the period of high inflation for Taiwan and Japan respectively. Both figures show that high inflation in the period from 1973 to 1974 had the strongest negative effect on the financial development and economic growth for both countries. For example, in the case of Taiwan, when inflation reaches its highest level of 61.41% in the first quarter of 1974, the degree of financial development and economic growth were the lowest, they were, -23.13% in the first quarter of 1974 and -14.02% in the last quarter of 1974, respectively. As for Japan, the highest inflation rate during the period from 1973 to 1974 was 23.45% in the third quarter of 1974, and lowest degree of financial development and economic growth were -7.69% in the third quarter of 1974 and -4.66% in the last quarter of 1974, respectively. Both countries experience low and moderate inflation after 1981, and inflation was generally stable in the 90s.

[9] The East Asian Miracle: Economic Growth and Public Policy, A World Bank Policy Research Report, 1993, pp.131-134.

[10] The financial liberalization process in Taiwan could be divided in three stages. First, interest rate liberalization started in the early 1980s; second, the foreign exchange system was converted from a fixed rate system to a management flexible rate system in 1979. Third, the liberalization of the securities market started in 1988.

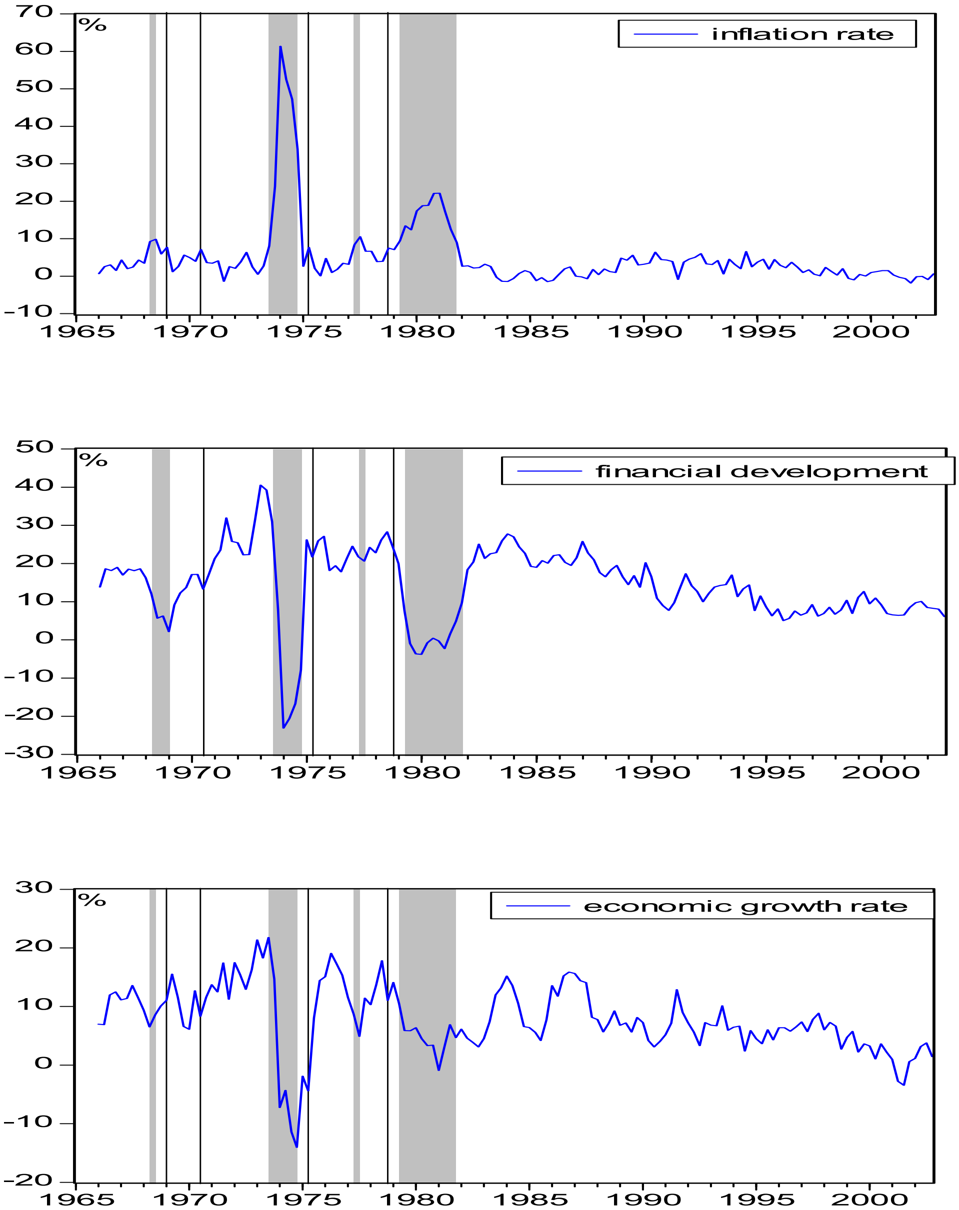

Figure 1. Plot of Inflation Rate, Financial Development and Economic Growth by Inflation Threshold for Taiwan

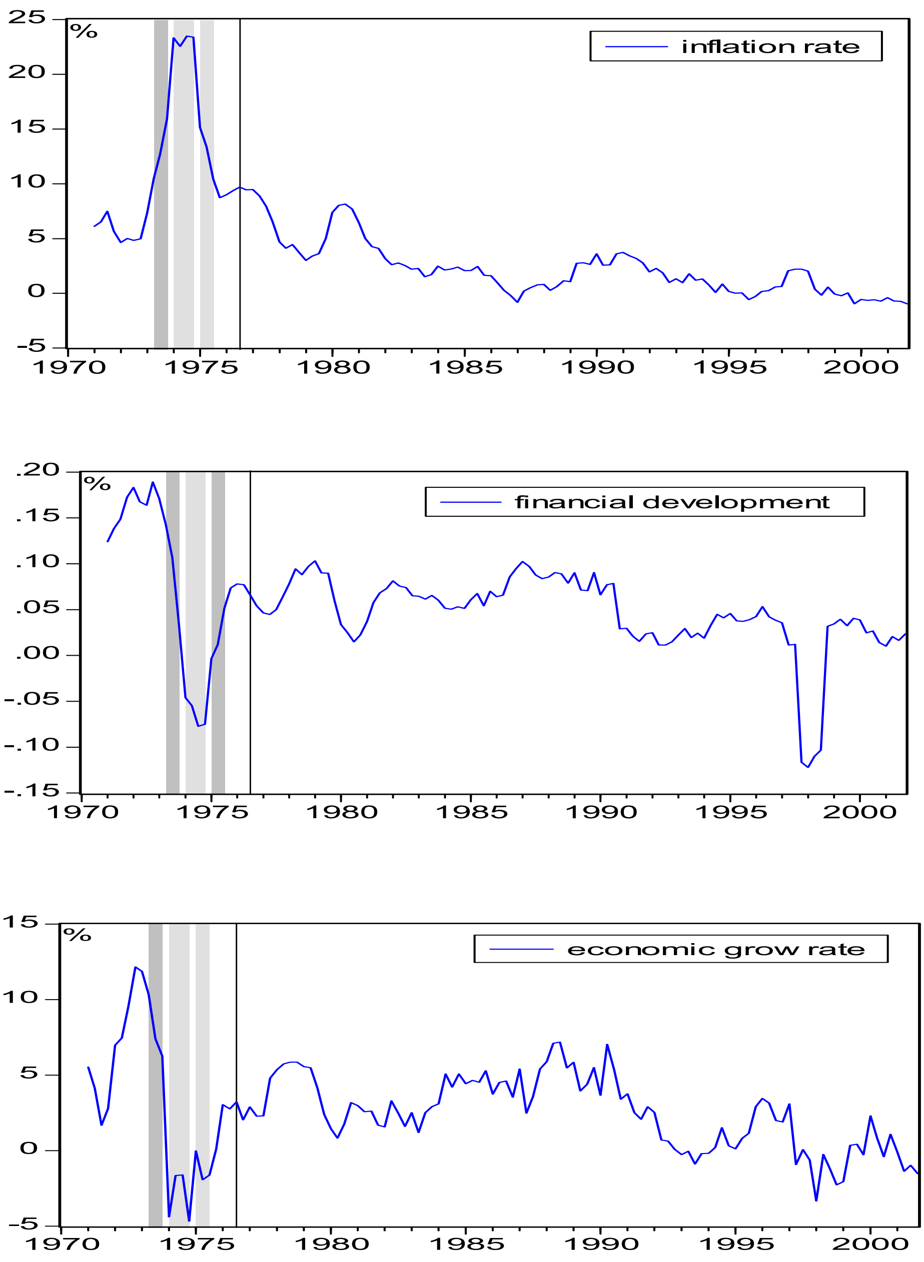

Figure 2. Plot of Inflation Rate, Financial Development and Economic Growth by Inflation Threshold for Japan

4. CONCLUSIONS AND POLICY IMPLICATIONS

According to the theoretical studies of Huybens and Smith (1999), Gylfason and Herbertsson (2001), and Bose (2002), inflation will affect real economic activities through its impact on the financial market. De Gregorior and Guidotti (1995) also produced similar results for Latin American countries. That is, when Latin America countries underwent high inflation rate in the 1970s and 1980s, financial development retarded economic growth. The aim of this study is to broaden the empirical literature on the relationship between inflation, financial development, and economic growth by investigating the relationship among these three variables for Taiwan and Japan. Toward this regard, we employed the TAR approach introduced by Tong (1978) and Hansen (1996) to investigate the possible inflationary threshold effects in the relationship between financial development and economic growth. The empirical findings of this study show that there is one inflation threshold value in Taiwan, whereas there are two in Japan.

By treating the annual growth rate of inflation as the threshold variable and exploring the effects of financial development on economic growth under different inflation regimes, the estimation results suggest that when the threshold level of inflation is below 7.25%, financial development may promote economic growth for Taiwan. However, when inflation is higher than 7.25%, financial development will not generate any significant impact on economic growth. Consequently, financial development that promotes economic growth can only be established under low inflation. As for Japan, The empirical results suggest that when the threshold level of inflation is below 9.66%, financial development has a significantly profound impact on economic growth. However, financial development is detrimental to economic growth when inflation is above the threshold level. As a result, the conclusion that financial development may promote economic growth can be established only when Japan’s inflation rate is low or moderate. This conclusion is consistent with the findings of Huybens and Smith (1999), Bose (2002), and Rousseau and Wachtel (2002).

The estimated results obtain in this study suggest that inflationary threshold indeed exists in the relationship between financial development and economic growth in Taiwan and Japan. This implies that changes in inflation contribute one of the factors that cause structural change in the relationship between financial development and economic growth. Therefore, this structural change due to the existence of inflationary threshold should be taken into account when constructing estimation and prediction models of economic growth for Taiwan and Japan. Furthermore, the policy implication derived from this study is that before policymakers adopt any policy to promote or accelerate financial development, the role of inflation should not be neglected in the relationship between financial development and economic growth; otherwise, such a policy may be detrimental to economic growth.

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Mailing Address: Chien-Chiang Lee, Department of Applied Economics National Chung Hsing University 250 Kuo-Kuang Rd., Taichung, Taiwan 402, R.O.C. Tel: +886-4-2284-0352 ext. 308, Fax: +886-4-2287-0203. E-mail: ccl@nchu.edu.tw.

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