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(出版者 / Publisher)
法政大学比較経済研究所 / Institute of Comparative Economic Studies, Hosei University

(雑誌名 / Journal or Publication Title)
Journal of International Economic Studies / Journal of International Economic Studies

(巻 / Volume)
17

(開始ページ / Start Page)
129

(終了ページ / End Page)
137

(発行年 / Year)
2003-03

(URL)
https://doi.org/10.15002/00002487

Journal of International Economic Studies (2003), No. 17, 129–137

Structural Breaks and Currency Crises: A Stylized Fact*

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Abstract

This paper analyzes the effects of currency crises on output, estimating structural breaks. The breaking dates are estimated by Bai and Perron's (1998) method, which allows us to seek the dates and numbers of structural breaks. Furthermore, we compare the estimated break points with Goldstein, Kaminsky and Reinhart's (2000) results on the dates of banking and currency crises. This is then used to investigate the relation between these structural changes and crises. The findings of our estimation are (i) there exist cases in which currency crises might affect real variables, and (ii) banking crises are seldom related to structural breaks.

KEYWORDS: Currency crisis, twin crises, emerging markets, multiple structural changes.

1. Introduction

Since the 1980s, numerous analyses of currency crises have appeared in economic journals. Most of these papers have looked at the timing or causality of crises. Currency crises have been seen as a serious problem, especially in emerging markets, since they usually cause turmoil in the stricken country. In the 1990s, some papers have insisted on the existence of a self-fulfilling feature of currency crises[1] .

In comparison with these issues, the effects of currency crises on the real economy have been rarely discussed. With regard to the effects of inflation, Barro (1997) estimates the negative effects of relatively high inflation rates on economic growth. This result implies that a sharp depreciation affects economic variables, because a monetary authority cannot maintain a high inflation rate as long as the exchange rate is pegged. Other theoretical considerations of inflation have been published, e.g., Tobin (1965), Sidrauski (1967a and b), Gomme (1993), Jones and Manuelli (1995), and Boyd and Smith (1998)[2] .

However, some recent papers on currency crises offer empirical results that differ from these intuitions. Park and Lee (2001) studied whether the growth rates of per capita real GDP vary between pre- and post-crisis periods, using panel data of the East Asian countries during the period from 1970 to 1995. They conclude that the currency crisis had no long-run effect in these countries[3] . At the same time, they investigated cases where IMF programs

*I thank Hideki Izawa, Eiji Ogawa, Yoshinori Shimizu, Masayoshi Tsurumi, and an anonymous referee for their valuable comments. Any remaining errors are mine.

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were adopted, finding that in these cases the effects were also insignificant. On the other hand, Barro (2001) extends Park and Lee's (2001) estimation to show that although the growth rates of the East Asian countries slowed after the Asian financial crises in 1997, in general, currency crises have little effect on economic growth. Moreover, Chou and Chao (2001) estimate the cointegrated relations between changes in exchange rates and real variables in order to find the long-term relations among these variables. Using a panel unit root test, they conclude there is no long-term relation.

These results may suggest that currency crises affect real variables temporarily, but not permanently. In other words, the real economy may recover in a short period and return to its steady state. However, these studies do not consider structural breaks. If currency crises cause structural breaks in real variables, it would be difficult to estimate the effect of crises over a short period. Thus, in the presence of long-term effects on the real economy, currency crises can be a serious problem.

This paper analyzes the effects of currency crises on output, estimating structural breaks. The breaking dates are estimated by Bai and Perron's (1998) method, which allows us to seek the dates and numbers of structural breaks. Furthermore, we compare the estimated break points with Goldstein, Kaminsky and Reinhart's (2000) results on the dates of banking and currency crises. This is then used to investigate the relation between these structural changes and currency crises.

Our findings are as follows. First, there exist cases in which currency crises might affect real variables, but this is not true for all cases. Countries in the presence of structural changes have experienced currency crises in the confidence intervals of breaks. The structural breaks of emerging markets, in particular, seem to relate to currency crises. Second, banking crises are seldom related to structural breaks. Kaminsky and Reinhart (1999) investigate banking and currency crises and insist on a strong relationship between the two. They call this "twin crises." From the results of this paper, the structural breaks of real variables seem to have been affected by currency crises rather than twin crises.

The rest of the paper is organized as follows. In the next section, we use Bai and Perron's (1998) test of multiple structural changes to investigate the effects of currency crises on output. In Section 3, we estimate the index of currency crises and compare the dates of the structural changes and crises. Furthermore, we calculate the growth rates of output in each regime. Finally, conclusions are contained in Section 4.

2. Estimating Structural Changes

2.1 The Model

In this section, we analyze the structural breaks of output[4] . Bai and Perron (1998) propose a methodology that estimates break points and dates such that the sum of squared residuals is minimized, extending the methodology of Andrews (1993). The model in this paper is a special case of Bai and Perron's general linear model, which has structural breaks in constant. Let, initially, output in period t, y_t, be generated by the following pth order autoregressive process, AR(p):

$$\Delta \log y_t = \mu_J + \beta_1 \Delta \log y_{t-1} + \cdots + \beta_p \Delta \log y_{t-p} + \epsilon_t. \tag{1}$$

where μ_J is a constant in the Jth regime and ϵ_t is the i.i.d. error term. That is, Equation (1) is an AR(p) process that has different constants in different regimes. In order to make the estimation simple, we transform Equation (1) to

$$\mathbf{y} = \left[\mathbf{y}_{-1}, \cdots, \mathbf{y}_{-p}, \iota\right] \begin{bmatrix}\beta \\ \gamma_0\end{bmatrix} + \mathbf{du}(T_1)\gamma_1 + \mathbf{du}(T_2)\gamma_2 + \cdots + \mathbf{du}(T_m)\gamma_m + \epsilon, \quad (2)$$

where

$$\mathbf{y} = \begin{bmatrix}\Delta \log y_{p+1} \\ \vdots \\ \Delta \log y_T\end{bmatrix}, \quad \mathbf{y}_{-1} = \begin{bmatrix}\Delta \log y_p \\ \vdots \\ \Delta \log y_{T-1}\end{bmatrix}, \quad \cdots, \quad \mathbf{y}_{-p} = \begin{bmatrix}\Delta \log y_1 \\ \vdots \\ \Delta \log y_{T-p}\end{bmatrix},$$

and

$$\iota = \begin{bmatrix}1 \\ \vdots \\ 1 \\ 1 \\ \vdots \\ 1 \\ 1 \\ \vdots \\ 1\end{bmatrix}, \quad \mathbf{du}(T_1) = \begin{bmatrix}0 \\ \vdots \\ 0 \\ 1 \\ \vdots \\ 1 \\ 1 \\ \vdots \\ 1\end{bmatrix}, \quad \mathbf{du}(T_2) = \begin{bmatrix}0 \\ \vdots \\ 0 \\ 0 \\ \vdots \\ 0 \\ 1 \\ \vdots \\ 1\end{bmatrix}, \cdots.$$

β is a $p \times 1$ vector, γ_0 is a coefficient of ones, and $\gamma_1, \cdots, \gamma_m$ are coefficients of $\mathbf{du}(\cdot)$. Let $S_T(T_1, \cdots, T_m)$ be the sum of squared residuals given m break points $(T_1, \cdots, T_m)$. So the optimal dates of break points such that $S_T(\cdot)$ is minimized are

$$(\hat{T}_1, \cdots, \hat{T}_m) = \arg \min_{T_1, \cdots, T_m} S_T(T_1, \cdots, T_m). \quad (3)$$

To estimate break points and their numbers, we begin with the null hypothesis $m = 0$ versus the alternative hypothesis $m = 1$. If the null hypothesis is rejected, then we go on to test $m = 1$ versus $m = 2$, and so on.

$$F_T(m+1|m) = \left[S_T(\hat{T}_1, \cdots, \hat{T}_m) - \min_{1 \le i \le m+1} \inf_{\tau \in \Lambda_{i,\eta}} S_T(\hat{T}_1, \cdots, \hat{T}_{i-1}, \tau, \hat{T}_i, \cdots, \hat{T}_m)\right] / \hat{\sigma}^2, \quad (4)$$

where

$$\Lambda_{i,\eta} = \left\{\tau | \hat{T}_{i-1} + (\hat{T}_i - \hat{T}_{i-1})\eta \le \tau \le \hat{T}_i - (\hat{T}_i - \hat{T}_{i-1})\eta\right\}$$

and $\hat{\sigma}^2$ is a consistent estimate of σ^2. Critical values with $\eta = 0.05$ are tabulated by Table II in Bai and Perron (1998).

Data are drawn from Kaminsky and Reinhart's database. The output data are industrial production (see Data Appendix of Kaminsky and Reinhart (1999)). This database contains 20 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Denmark, Finland, Indonesia, Israel, Malaysia, Mexico, Norway, Peru, Philippines, Spain, Sweden, Thailand, Turkey, Uruguay, and Venezuela. The period of the data is from 1970 to 1997.

Table 1.a Results

H0	H1	Argentina	Bolivia	Brazil	Chile	Colombia	Denmark	Finland	Indonesia	Israel	Malaysia	critical value (90%)
0	1	7.01	4.54	11.34	8.36	4.68	2.27	3.02	5.16	9.35	2.76	8.02
1	2			19.53	14.00					4.78		9.56
2	3			40.15	12.81							10.45
3	4			9.59	6.28							11.07
break dates				Dec.1980	Dec.1974					Dec.1971		
				Feb.1981	Feb.1975							
				Dec.1981	Dec.1975							

Table 1.b Results

H0	H1	Mexico	Norway	Peru	Philippines	Spain	Sweden	Thailand	Turkey	Uruguay	Venezuela	critical value (90%)
0	1	12.44	5.01	2.28	2.16	8.48	5.13	9.70	3.56	2.43	3.29	8.02
1	2	11.46				5.56		9.61				9.56
2	3	16.16						7.55				10.45
3	4	9.92										11.07
break dates		Dec.1981				Nov.1973		Nov.1986				
		Feb.1982						Dec.1995				
		Dec.1983										

Note: These estimations are of structural changes of outputs, using Bai and Perron's (1998) method. The equations are assumed AR(6) processes. The critical values are tabulated by Bai and Perron.

The results of the test with $\eta = 0.05$ are shown in Table 1. Structural breaks are estimated for six of the twenty countries, almost all of which are emerging market countries (Brazil, Chile, Israel, Mexico, and Thailand). The dates of structural breaks vary in these countries. This may imply that there was no real effect of contagion, which means a crisis spreading from one country into other countries. If there are real effects of contagion, then most countries would have structural changes in the same period. However, this is validated by this test.

3. Breaks, Crises, and Growth Rates

3.1 Structural Changes and Crises

Here, we compare the estimated break dates and the dates of currency crises and banking crises. The dates of currency crises are estimated by the following methodology. Eichengreen, Rose and Wyplosz (1996), Kaminsky and Reinhart (1999), and other many empirical researches use an index,

$$\mathrm{IND}_t = \frac{\Delta s_t}{s_t} - \frac{\sigma_{\Delta s/s}}{\sigma_{\Delta R/R}} \frac{\Delta R_t}{R_t}, \tag{5}$$

where s_t is foreign exchange rate, R_t is foreign reserves, and $\sigma_{\Delta s/s}$ and $\sigma_{\Delta R/R}$ are the standard deviations of $\Delta s_t/s_t$ and $\Delta R_t/R_t$, respectively. Following previous studies, a currency crisis is defined as a case where the index reaches a threshold, for instance, in its standard deviation. This index is a weighted average of the changes in exchange rates and foreign reserves. Since the weights are standard deviations, the more volatile the changes in the past, the smaller the weights is, that is, the changes have less effect on the index. In contrast, the index increases as the volatility of these variables increases. We regard a currency crisis to exist when the index exceeds its standard deviation. In Goldstein, Kaminsky and Reinhart (2000), the threshold is three standard deviations. However we use one standard deviation because the stricter threshold often rejects some well-known currency crises, e.g., Israel's in 1971[5] .

Next, the dates of banking crises must be estimated. We use Goldstein, Kaminsky and Reinhart's (2000, Table 2.2) data to specify the dates. They mark the dates based on events, such as bank runs, closures, etc.

Moreover, if the date of a crisis is within the confidence interval of a break point, then we consider the structural break to be related to the crisis. The 90% confidence intervals were obtained using 10,000 simulations and 4,000 steps to approximate the Wiener processes. As a result of this simulation, some break points in Brazil, Chile, and Thailand were found to be on the intervals of other breaks. With respect to break points, however, we look for crises in the confidence intervals.

Table 2 shows the structural break dates estimated above, along with the dates of currency crises and banking crises. It shows that all of these countries experienced structural changes and currency crises in the same period. The 1982 currency crisis of Brazil, for example, is within the confidence interval of the structural change in 1981. This implies that these structural breaks are related to the currency crises.

Kaminsky and Reinhart (1999) point out that in the 1970s, currency crises and banking crises were not related, but since the 1980s, they have been strongly related. According to

Table 2 Structural Changes and Financial Crises

country	structural change	currency crisis	banking crisis
Brazil	Dec.1980		
	Feb.1981	Nov.1980	
	Dec.1981		
Chile	Dec.1974	Dec.1974	
	Feb.1975		
	Dec.1975	Dec.1975	
Israel	Dec.1971	Aug.1971	
Mexico	Dec.1981		
	Jan.1982	Jan.1982	Sep.1982
	Dec.1983		
Spain	Nov.1973	Jan.1974	
Thailand	Nov.1986		
	Dec.1995	Jul.1997	May.1996

Table 2, in only two of six countries were the banking crisis within the confidence interval: Mexico and Thailand. The other four countries have not experienced banking crises or twin crises. This shows that banking crises are seldom related to structural changes of output. Therefore, structural breaks depend on currency crises, rather than banking crises or twin crises.

Our findings are different from those of many previous papers. Barro (2001), Park and Lee (2001), and Chou and Chao (2001), for instance, suggest that currency crises have little long-term effect on the real sector. Furthermore, since our data does not cover the sample in the period of the Asian financial crisis (1997-98), it is possible that, given a sufficiently large sample, we might find breaks in some East Asian countries.

3.2 Growth Rates

Goldstein, Kaminsky and Reinhart (2000) study the aftermath of currency and banking crises, and report the length of recovery from crises. Most economic indicators recover more sluggishly from banking crises than currency crises. However, the results estimated above imply that some currency crises cause long-term effects on economic variables.

The specification of this model allows us to estimate the rates of growth. As our model is an AR(p) process, the annual growth rate in the Jth regime is

$$12 \cdot \mu_J/(1 - \beta_1 - \cdots - \beta_p).$$

The results are shown in Table 3. For all of these countries, at least in the short term, there are large decreases of growth rates. In Brazil, Chile, and Mexico, the rates are in the double digits. The departures of the first regime and last regime, on the other hand, are negative, except for Chile, where the growth rate increases. This implies that the long-run effects of currency crises may be asymmetric, or that other factors might have promoted output growth. It is necessary to discuss this point further, theoretically and empirically.

Table 3 Growth Rates

	regime	growth rate
Brazil	1	8.43%
	2	−64.38%
	3	−58.32%
	4	3.24%
Chile	1	0.63%
	2	20.58%
	3	−45.66%
	4	6.09%
Israel	1	11.46%
	2	3.63%
Mexico	1	6.60%
	2	−30.42%
	3	−25.89%
	4	2.34%
Spain	1	7.38%
	2	2.19%
Thailand	1	5.94%
	2	−3.90%
	3	−0.27%

4. Concluding Remarks

This paper used Bai and Perron's (1998) test of multiple structural changes to investigate the effects of currency crises on output. In the countries studied by Kaminsky and Reinhart (1999), we found structural changes in some countries. All of the emerging market countries among them have experienced currency crises within the confidence intervals of the breaks. This implies that structural changes in emerging markets are related to currency crises. However, banking crises do not strongly relate to breaks.

It follows from these results that currency crises may negatively affect real variables. Particularly in the short run, currency crises have a large effect on output. This means that if an emerging market's currency suffers speculative attacks, the parity must be defended as quickly as possible. It is, of course, important to maintain fundamentals that are consistent with the exchange rate system, in order to peg the exchange rate. Since self-fulfilling currency crises cannot be entirely rejected, however, there may be cases where crises are caused by non-fundamental factors. Thus, both preventing currency crises from breaking out and stemming the tide of crises are still serious problems.

Note that it does not necessarily follow that all currency crises are related to structural breaks. That is, there may be a need for other factors. The purpose of this paper is to find a relationship between structural breaks and crisis. Of course, it is necessary to uncover how these crises affected the real sector: however, we will take this matter up at a future opportunity.

Notes

1 See Flood and Marion (2000) and Rangvid (2001) for recent developments in crisis theory.
2 For an excellent survey, see Orphanides and Solow (1990).
3 Edwards (1986) studied the impact of exchange rate depreciation on output, but found that it was small.
4 The following specification is based on unpublished lecture notes by Professor Michio Hatanaka.
5 This crisis is reported by Edwards (1989).

References

ANDREWS, DONALD (1993), "Tests for Parameter Instability and Structural Change with Unknown Change Point," *Econometrica* 61(4), pp.821-856.

BAI, JUSHAN AND PIERRE PERRON (1988), "Estimating and Testing Linear Models with Multiple Structural Changes," *Econometrica* 66(1), pp.47-78.

BARRO, ROBERT J. (1997), *Determinants of Economic Growth: A Cross-Country Empirical Study*, MIT Press.

BARRO, ROBERT J. (2001), "Economic Growth in East Asia Before and After the Financial Crisis," *NBER Working Paper* 8330.

BOYD, JOHN H. AND BRUCE D. SMITH (1998), "Capital Market Imperfections in a Monetary Growth Model," *Economic Theory* 11, pp.241-273.

CHOU, WIN LIN AND CHI-CHUR CHAO (2001), "Are Currency Devaluations Effective? A Panel Unit Root Test," *Economics Letters* 72, pp.19-25.

EDWARDS, SEBASTIAN (1986), "Are Devaluations Contractionary?" *Review of Economics and Statistics* 68, pp.501-508.

EDWARDS, SEBASTIAN (1989), *Real Exchange Rates, Devaluation, and Adjustment: Exchange Rate Policy in Developing Countries*, Cambridge, Mass: MIT Press.

EICHENGREEN, BARRY, ANDREW K. ROSE AND CHARLES WYPLOSZ (1996), "Contagious Currency Crises," *NBER Working Paper* 5681.

FLOOD, ROBERT P. AND NANCY P. MARION (2001), "Perspectives on the Recent Currency Crisis Literature," in Guillermo A. Calvo, Rudi Dornbusch and Maurice Obstfeld (eds.), *Money, Capital Mobility, and Trade: Essays in Honor of Robert A. Mundell*, MIT Press.

GOLDSTEIN, MORRIS, GRACIELA L. KAMINSKY AND CARMEN M. REINHART (2000), *Assessing Financial Vulnerability: An Early Warning System for Emerging Markets*, Institute for International Economics, Washington, DC.

GOMME, PAUL (1993), "Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model," *Journal of Monetary Economics* 32, pp.51-77.

GREENE, JOSHUA E. (2002), "The Output Decline in Asian Crisis Countries: Investment Aspects," *IMF Working Paper* WP/02/25.

JONES, LARRY E. AND RODOLFO E. MANUELLI (1995), "Growth and the Effects of Inflation," *Journal of Economic Dynamics and Control* 19, pp.1405-1428.

KAMINSKY, GRACIELA L. AND CARMEN M. REINHART (1999), "The Twin Cises: The Causes of Banking and Balance-of-Payments Problems," *American Economic Review* 89(3), pp.473-500.

LAHIRI, AMARTYA AND CARLOS A. VEGH (2000), "Output Costs, BOP Crises, and Optimal Interest Rate Policy," mimeo, UCLA.

ORPHANIDES, ATHANASIOS AND ROBERT M. SOLOW (1990), "Money, Inflation and Growth," B. M. Friedman and F. H. Hahn (eds.), *Handbook of Monetary Economics*, Vol.1, pp.223-261.

PARK, YUNG CHUL AND JONG-WHA LEE (2001), "Recovery and Sustainability in East Asia," *NBER Working Paper* 8373.

RANGVID, JESPER (2001), "Second Generation Models of Currency Crises," *Journal of Economic Surveys* 15(5), pp.613-634.

SIDRAUSKI, MIGUEL (1967a), "Inflation and Economic Growth," *Journal of Political Economy* 75, pp.796-810.

SIDRAUSKI, MIGUEL (1967b), "Rational Choice and Patterns of Growth in a Monetary Economy," *American Economic Review Papers and Proceedings* 57, pp.534-544.

TOBIN, JAMES (1965), "Money and Economic Growth," *Econometrica* 33(4), pp.671-684.