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Intertemporal Balance, Sustainability and Efficiency of the Exchange Rate Mechanism

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Abstract

Under the assumption that the balance of payments must satisfy the expected intertemporal balance, this paper seeks to establish a pre-condition for a crisis of the Exchange Rate Mechanism (ERM). Proposing that non-stationarity of the growth rate of assets is evidence of a violation of expected intertemporal balance, we calculate Augmented Dickey-Fuller statistics of the growth rate of foreign exchange reserves prior to the ERM crisis in September, 1992 for member states. In all, but one, of the crisis experiences, there is no evidence of a violation of intertemporal balance prior to the month of the crisis. However, the persistent violation of intertemporal balance by Italy prior to the crisis reflects that the fundamental disequilibrium matters to the viability of the ERM. With no evidence of efficient allocation of the foreign reserves within the member states, the ERM is exposed to attack by speculators. (JEL Classification: F31, F33)

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I. Introduction

The recent currency crises in Thailand, Mexico, and in the Exchange Rate Mechanism (ERM) have revitalized an interest in studying the balance of payment crisis and the speculative attack on the pegged exchange rate regime. General agreement is that fundamental disequilibrium results from inconsistent policies, which are not compatible with the pegged rate regime. With depleting (or accumulating) foreign reserves, the monetary authority confronts a dilemma of either abandoning the pegged rate regime, or retaining it by changing other policies. When the public perceives that the stock of the foreign reserves has reached the tolerable bound set by the monetary authority, the speculative attack will precipitate a collapse. Furthermore, if the monetary authority envisages that the cost of retaining the pegged rate regime outweighs the benefit of defending it, the rational public, knowing the intention of the monetary authority, will induce a self-fulfilling attack.[1]

Unlike other crises, the crises of the ERM in the fall of 1992 is a distinguished one. To join the Economic and Monetary Union(EMU), each member state has to possess a healthy economic structure in order to meet the convergence criteria (on inflation, budget deficits, exchange rate, and interest rates) postulated in the Maastricht Treaty. One of the requirements is that the exchange rate of each member state needs to observe normal fluctuation margins provided by the ERM.[2] With commitment to a self-disci-

1. The speculative attack and collapse of the fixed rate regime was pioneered by Krugman [1979]. There are two arguments when discussing this issue. One is based on the fundamental disequilibrium, and the surveyed articles could be found in Agénor, Bhandari, and Flood [1992], and Blackburn and Sola [1993]. The other stresses that the speculative attack is not necessarily triggered by fundamental disequilibrium and a self-fulfilling speculative attack can be expected and completed arbitrarily by the herding behavior of the public. Examples could be found in Obstfeld [1986, 1994,

plined policy, joining the ERM does help narrow the inflation and interest rate differentials among the member states.[3] However, the long-lasting incompatible policies of the member state could undermine its central rate. Consequently, a realignment is needed for the member states, otherwise the viability of the ERM might be threatened. During the ERM's 1992 crisis, Britain and Italy withdrew from the ERM, Spain devalued its central parity, and the Irish punt and the Portuguese escudo both weathered the crisis after imposing capital control. The currencies of Belgium, Denmark, France, and Holland, though, all survived the crisis, all four faced the greater pressure of speculative attack.[4]

Existing models of exchange rate collapse are based on the paper by Krugman [1979], in which he assumed a lower bound on reserves and a monetary policy under which reserves were systematically declining. He showed that the timing of exchange rate collapse was predictable and coincident with a speculative attack on reserves in which reserves are driven to their lower bound. This model has been extended and empirically implemented. The empirical implementations show a rising probability of collapse as the actual collapse date nears.[5]

Given that upper and lower bounds on reserves, and implicitly the decision to abandon the fixed exchange rate, are policy decisions for each individual member state, we suggest a pre-condition for an exchange rate crisis.[6] Economic theory implies such a pre-condition when the collapse is

3. During the crisis, Spain and Italy still reveal significant inflation differentials relative to other member states, which have been interpreted as loss of competitiveness. In most member states, the interest rate differentials do converge since the EMS was founded. However, the ERM encourages "convergence play", which enables speculators to borrow funds from the countries with relatively low interest rate such as Germany, and invest in high-yield countries such as Italy and Spain since the risk of exchange rate depreciation is overestimated.

triggered by fundamentals. Consider the official settlements account of the balance of payments. A “no-Ponzi game” condition on reserve debt together with an optimality condition, limiting the desirability of indefinitely accumulating reserves, implies expected intertemporal balance on the official settlements account. That is, when current policies lead to a failure of expected intertemporal balance, some policies are eventually changed. One policy subject to change is the current level of the exchange rate. Therefore, our hypothesis is that exchange rate collapse can be the result of a failure of intertemporal balance, given current behavior and policy.[7]

The pre-condition for exchange rate collapse can also be used to predict speculative activity on the foreign exchange market. When agents obtain evidence of a violation of expected intertemporal balance, they could reasonably anticipate an exchange rate collapse and attack. Therefore, we expect that exchange rate collapse is preceded by evidence of a violation of intertemporal balance, which creates a speculative attack on reserves. It is important to note that, at the point of attack, a violation of expected intertemporal balance is neither a necessary nor sufficient condition for an exchange rate change. It is not necessary because exchange rate change could be the consequence of a multi-part policy change from an initial point of expected intertemporal balance. In this case, the exchange rate change is unlikely to be accompanied by speculative attack, as agents are not likely to acquire advance information of the policy change. A violation of expected intertemporal balance is not sufficient for the exchange rate change because governments could decide to change other policies to achieve expected intertemporal balance. Therefore, the frequency with which a failure of intertemporal balance triggers exchange rate collapse and the frequency with which exchange rate collapse is preceded by a failure of intertemporal balance are both empirical questions.

that a sufficient condition for intertemporal budget balance is that the first difference of debt is stationary. However, stationarity of the first difference of debt is not a necessary condition for the intertemporal budget balance. We propose that a necessary condition for the violation of intertemporal balance is that the growth rate of government debt is non-stationary. Therefore, in the context of the official settlements account, non-stationary behavior of the growth rate of reserves could generate expectations that policy will change, triggering speculative attack and collapse.

In this paper we present a time series of Augmented Dickey-Fuller (ADF) statistics, constructed with a fixed sample size, which rolls through each series. This allows us to determine the timing of evidence of non-stationary behavior, and implicitly of expectations of policy change. The sample consists of monthly data for seven countries in the ERM in which their parity either ends or is seriously threatened during the crisis in the Fall of 1992. There are crises in which a country's reserves were falling, as well as crises in which a country's reserves were rising.

To investigate the sustainability of the ERM, it is important to know that the crisis of the individual state is not sufficient for the ERM to collapse. With concerted intervention by the central banks from the member states, it will be able to avoid the collapse triggered by an individual state.[8] Fisher [1996] proposes that the cointegration of the foreign exchange reserves within the member states under a system of fixed rates implies an efficient allocation. The cointegration relation implies that there exists efficient intergenerational exchange among the member states. Economically speaking, the consideration of efficiency justifies, at least, the purposes of the ERM.

The remainder of this paper is organized as follows. Section II, summarizes Trehan and Walsh's argument that the intertemporal budget balance requires stationarity of the first difference of debt, then proposes a necescient allocation in the ERM. Section III presents the empirical results, and Section IV contains conclusions.

II. Motivation for Empirical Tests

A. Intertemporal Budget Balance and Stationarity

Trehan and Walsh [1991] use the time series behavior of the stock of U.S. government debt to determine whether the U.S. government budget constraint is expected to be intertemporally balanced. The equation for the change in debt is given by:

$$s_t - s_{t-1} = r_t s_{t-1} + d_t \qquad (1)$$

where s_t is the real stock of outstanding debt (assets if negative) at the end of period t, r_t is the real rate of interest during the period, and d_t is the fundamental deficit, that is, revenues minus expenditures exclusive of interest on the debt.

The equation for expected intertemporal budget balance can be derived by solving equation (1) forward for s_{t-1}, and taking expectations conditional on information available at $t-1$. This yields:

$$s_{t-1} = -\sum_{j=0}^{\infty} E(\, {}^{-1}_{t+j} d_{t+j} | I_{t-1}) + \lim_{j \to \infty} E(\, {}^{-1}_{t+j} s_{t+j} | I_{t-1}). \qquad (2)$$

where $\rho_{t+j} = \prod_{i=0}^{j} (1+r_{t+i})$ is the j-period discount factor from time t to $t+j$. The expectation of intertemporal budget balance requires that the last term be zero, yielding the transversality condition:

$$\lim_{j \to \infty} E(\, {}^{-1}_{t+j} s_{t+j} | I_{t-1}) = 0. \qquad (3)$$

then expected intertemporal budget balance is satisfied. However, as indicated in Trehan and Walsh, the stationarity of $s_t - s_{t-1}$ is only a sufficient condition, not a necessary condition for the intertemporal balance to be held. What we are interested in is to find a sufficient condition for the violation of the intertemporal balance. Intuitively, equation (3) indicates that if s_t grows faster than ρ_t, then intertemporal balance will not be held since the limit of the product of the two will not approach zero. Huang and Lin [1993], and Campbell and Mankiw [1989] loglinearize the intertemporal balance equation. Under the assumption of no-Ponzi game, therefore, equation (2) could be rewritten as

$$lns_t - lns_{t-1} = r_t + \lambda_0 + \lambda_1 lnd_t - \lambda_2 lns_t, \qquad (4)$$

where ln represents taking natural log, and λ are the parameters from loglinearization. The non-stationarity of $lns_t - lns_{t-1}$ will not cause equation (3) to converge to zero, which violates our assumption of no-Ponzi game and therefore, the intertemporal balance.

Equation (2) can be used to discuss intertemporal balance on the official settlements account of the balance of payments. Interpret s_t as negative official reserves and d_t as the net-of-official-interest balance on the official settlements account. Equation (1) says that the change of reserves equals the interest paid (received) by the domestic monetary authority on its reserve debt (assets) plus a net-of-official-interest deficit (surplus) on the balance of the official settlements account. Intertemporal balance on the official settlements account requires that equation (3) hold with equality for reserves.

Empirically, if speculators have evidence that the stationarity condition is violated, they have reason to expect policy change, including the possible abandonment of the fixed exchange rate. Therefore, we test whether speculative attack and exchange rate collapse are preceded by evidence of non-

However, if speculative activity is a function of policy, then any non-stationarity reflects expected intertemporal imbalance, given current policy, since the current policy is the cause of the speculative activity. Alternatively, if non-stationary behavior can be created by arbitrary speculative activity, then the exchange rate crises could be self-fulfilling, and not induced by current policy. The evidence of a failure of intertemporal balance can be created by arbitrary speculative activity, leading to a self-fulfilling exchange rate crisis. Therefore, it is necessary to realize that a violation of expected intertemporal balance could be created by arbitrary speculative behavior instead of policy.[9]

It is important to know that during a crises within the ERM there exist reserve-accumulating and reserve-depleting members. As suggested by Fisher [1996], if there is efficient allocation in a system of fixed rates, there exists a cointegrated vector of the foreign exchange reserves among the member states. This cointegration relationship enables the member states to have intergenerational borrowing (lending) and reach efficiency. As a result, if there is a cointegration within the member states, the efficiency incentive might strengthen their willingness of maintaining the ERM.

B. Tests for Stationarity and Cointegration

Consider the empirical problem which speculators face at a point in time. They can use information on the time series behavior of reserves to determine whether there is an expected violation of intertemporal balance on the official settlements account. Therefore, to analyze the decision by speculators whether or not to attack reserves at time t, only information up until time t can be used. We use a time series of Augmented Dickey-Fuller (ADF) statistics to provide evidence on whether the behavior of the growth rate of reserves appears non-stationary at a point in time, given information up tics, we calculate the ADF statistics using a fixed sample size, which rolls through time. Banerjee, Lumsdaine and Stock [1992] proposed the use of “rolling” Dickey-Fuller statistics as a test for the stability of the coefficients in the Dickey-Fuller model. They were explicitly looking for evidence of stationarity around a trend with an unknown break date. They also had to calculate alternative critical values since the test relies on extremum of the ADF statistics.[10] This is not necessary for our test since we test the hypothesis of non-stationarity at each point in time.

For the efficiency test, we consider a cointegration test proposed by Johansen [1988]. Johansen’s test includes the trace test and the maximal eigenvalue statistic (λ_{max}). Since we use a small sample, it could be biased toward finding cointegration too often by using the critical values derived from asymptotic tests. Accordingly, we used adjusted critical values suggested by Cheung and Lai [1993].[11]

III. Empirical Evidence

A. Data

This sample is monthly from January 1987 to September 1992.[12] In each of the crises, the central parity either collapsed or was severely threatened. The time series behavior of rolling ADF statistics on the growth rate of reserves is investigated for Belgium, Denmark, France, Germany, Holland,

10. Evidence of an explicit trend break requires a sample following the break so that the new trend can be estimated. Banejee, Lumsdaine, and Stock [1992] proposed alternative statistics, which they labeled sequentially, for this purpose.
11. The way to make finite-sample corrections is to adjust the critical values by

$$CR_T / CR_\infty = T / (T-nk),$$

where CR_T, CR_∞, T, and k represent the approximate finite sample critical value

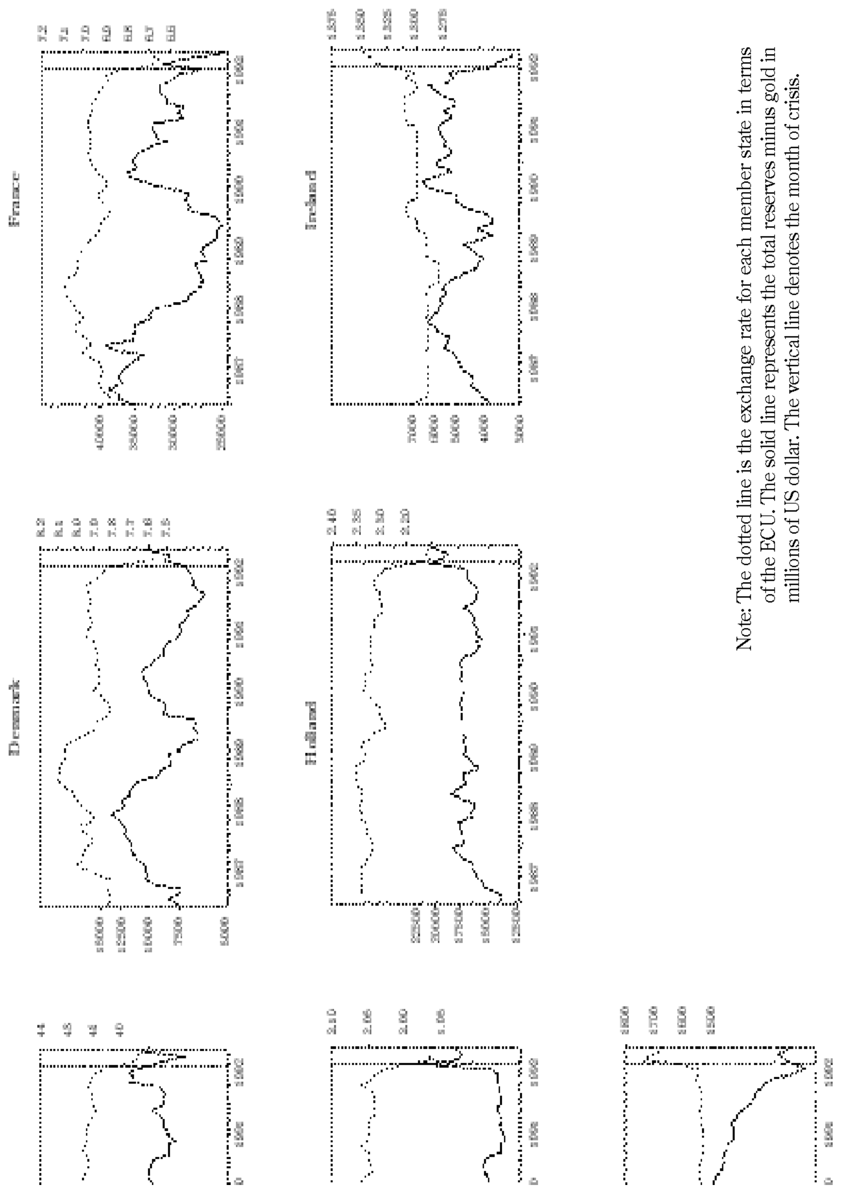
Ireland, and Italy. Spain did not join the ERM until June 1989, Britain did not enter until October 1990, and Portugal did not participate until April 1992. Because of the short sample size, these three countries' ADF statistics are not calculated. Of these crisis experiences, Belgium, Denmark, France, Ireland, and Italy experienced exchange rate crises due to deficits (losing reserves); while Germany and Holland experienced crises due to surpluses(gaining reserves).[13] The sample, therefore, contains a diverse set of experiences through which to investigate the relationship between evidence of non-stationarity of the growth rate of reserves (implicit violation of intertemporal balance) and exchange rate crisis and collapse.

The measure of reserves is the IMF's measure of total reserves minus gold. Gold is omitted due to valuation problems since it is valued for much of the period at the official price of $35 an ounce. Each country's reserves are measured in US dollars and deflated by the consumer price index to obtain real measures of reserves. Graphs of the real reserves, together with each country's European Currency Unit (ECU) exchange rate, are plotted in Figure 1. The period of exchange rate crisis is denoted by vertical lines.

B. Test Results and Discussion

For all countries, we present the results using a sample of five years, or 60 observations.[14] The ADF statistics are estimated through the regression with a constant term and rolling through fixed lags for each currency and each ADF statistic. As noted, the lags chosen for implementing the unit root test are influential for generating the estimated statistics. We claim that the speculator for each member state follows a simple rule to estimate whether the intertemporal balance has been violated. The ADF test focuses on obliterating the serial correlation. The simple rules for choosing lags, therefore, are

Figure 1



Note: The dotted line is the exchange rate for each member state in terms of the ECU. The solid line represents the total reserves minus gold in millions of US dollar. The vertical line denotes the month of crisis.

based on a Q-statistic, of which we require at least a 90% confidence interval for most of the estimated statistics. The lags for each member state are indicated in the bracket behind the name of the members in Table 1. The null of non-stationarity is rejected when the statistic falls below −2.91 at a 5% significance level and −2.59 at a 10% significance level MacKinnon [1991] . The confidence with which the null of non-stationarity can be rejected is greater as the ADF statistics gets lower. Therefore, we refer to loosely decreasing confidence for rejection of the null as increasing evidence of non-stationarity and vice versa. Table 1 contains expressions for the rolling ADF statistics nine months prior to each crisis and in the month of the 1992 crisis.

Before the crisis, the fundamental economic problem of Italy caught attention on many occasions. There is little wonder that the crisis starts in Italy. Our results agree with the general consensus. The rest of the member states have no sign of fundamental problems before the crisis, since there is no evidence of non-stationarity prior to the exchange rate crises. However, the sudden increase of the ADF statistics at the time of crisis implies speculative attacks. We will interpret the test results in three groups, first, the depleting reserves of Belgium, Denmark, France and Ireland, second, Italy,

Table 1

Rolling Dickey-Fuller Statistics[1]

period	Belgium(2)	Denmark(11)	France(1)	Germany(1)	Holland(1)	Ireland(3)	Italy(12)
Dec. 1991	–3.56**	–3.14**	–4.96**	–5.57**	–5.73**	–3.42**	–0.88
Jan. 1992	–3.70**	–2.84*	–5.08**	–6.53**	–5.84**	–3.27**	–0.77
Feb. 1992	–3.61**	–3.00**	–4.89**	–5.55**	–5.87**	–3.36**	–0.92
Mar. 1992	–3.61**	–2.74*	–4.91**	–5.15**	–6.01**	–3.46**	–0.66
Apr. 1992	–4.22**	–2.88*	–4.98**	–5.06**	–6.31**	–3.40**	–0.25
May 1992	–4.07**	–3.35**	–4.93**	–5.09**	–6.13**	–3.29**	–0.22
June 1992	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

and finally the reserve-accumulating states, Germany and Holland.[15]

In Belgium, starting from June the ADF statistics reject non-stationarity strongly by a 5% significance level. It arose when the National Bank of Belgium raised interest rates in order to dampen the speculative attack caused by the Danish referendum. This policy change forced the ADF statistics down as indicated in Table 1. In September 1992, the ADF statistic drops to –5.44, which rejects the non-stationary hypothesis for a 5% significance level. It is recorded that the prompt and large amount of reserves loss shows that there is foreign exchange market pressure from speculators. This controversial result could come from the monthly data which contributed to the data at the end of the period. This speculative movement will not be detected if it occurred in the beginning or in the middle of the period once the capital was repatriated after the crisis. The Belgian franc is fixed with the currency of Luxembourg which possesses a quite soundly-based economy; this might be another reason for its surviving the attack.

Though Denmark has been suffering from a trade deficit for years, its intertemporal balance is satisfied as indicated in Table 1.[16] Figure 1 reveals that Danish reserves have been depleting since 1991. This might be the reason that the ADF statistics of January, March, and April of 1992 have rejected non-stationarity only at the 10% significance level. Owing to the increase of interest rates at the National Bank of Denmark, June's referendum for Maastricht brings a rejection of the null hypothesis at a 5% confidence level. The interest rate starts to decrease in September when the government realizes that the cost of maintaining a high interest rate outweighs the benefits. Table 1 shows that the ADF statistic –2.97 weakly rejects the null hypothesis of non-stationarity. Owing to strong support from Germany, the Danish krone avoids speculative attack during the ERM crisis.[17]

Meanwhile, France had been trying hard to contain itself within the criteria of the Maastricht Treaty by sacrificing domestic stability. However, chronic domestic imbalance increases the cost of maintaining the fixed regime. Accidentally, the waves of the British and Italian crises transmit to France. Owing to the resolve of the French government, and the joint statement in support of French franc/mark parity between Bundesbank and Banque de France, France does not abandon its parity. In Table 1, all the ADF statistics reject the null hypothesis of non-stationarity. In September 1992, the ADF statistic is –4.55, which is a local minimum rejects the non-stationary hypothesis at a 5% significance level; this implies that the French franc confronts a highly speculative currency pressure.

Table 1 shows that the ADF statistics for Ireland, the last member of group 1, all reject the violation of intertemporal balance. In the month of the crisis, the ADF statistic is –2.62, which is a local maximum. This rejects non-stationarity only at a 10% significance level. By imposing capital control, Ireland prevents its punt from collapsing.

Of all the member states in the ERM, Italy has the largest inflation and interest rate differentials vis-à-vis Germany. There is no doubt that a crisis, if there is one, will probably originate in Italy.[18] On September 13, 1992, the lira devalued by 7.0 percent against other currencies in the ERM. On September 19, the lira was withdrawn from the ERM. The ADF statistics in Table 1 show that Italy has violated the intertemporal balance since December 1991. In addition, since the Danish referendum, the ADF statistics are boosted and then increase as the time of the collapse approaches. At the time of collapse, the ADF statistic could not reject the null hypothesis though it starts to decrease.

Turn, now, to group 3, the surplus countries. Let us consider Germany first. Germany is an anchor country in the ERM. During a crisis, the Gerrency attack on Germany. In Table 1, all the ADF statistics exhibit rejection of the null hypothesis of non-stationarity prior to the months of the crisis. However, in September 1992, the ADF statistic abruptly jumps to –1.42, which can not reject the null of non-stationarity. As an anchor state, Germany plays a role similar to the United States in the Bretton Woods system. Unlike other member states, the non-sustainability of the German intertemporal balance can put the ERM in jeopardy. At this moment, the German authority should either change policy to maintain central parity, or realign their central parity. As noted, most of the member states would not agree to let Germany revalue its undervalued currency. The dilemma comes when Germany does not abandon its stable-price policy. The adjustment that must be made will affect weak economies, like Italy, first.

Finally, we turn to Holland. The monetary authority of Holland gains its credibility through fixing its interest rate to the D-mark. It comes as no surprise that Holland's ADF statistics since December 1991 all reject the non-stationarity hypothesis as denoted in Table 1. During the crisis, the foreign reserves of Holland increase. However, Holland pegged its monetary policy to Germany and attains similar results. There are no violations of the intertemporal balance nine months before the crisis. In September, Holland

Table 2

Cointegration Test[1]

λ_{max} test					
	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
CR. 95%	47.40	38.35	29.71	19.93	5.33
	31.63	20.47	11.28	6.40	0.00
trace test					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

faces the pressure of capital inflow. Like Germany, the ADF statistics still reject the null hypothesis though the statistic jumps up to –4.72.

For testing efficiency, the results of Johansen's test are listed in Table 2. Note that the sample period starts in January 1987 and ends in August 1992. We do not extend the sample into September 1992 because of the unstable results for most of the member states during September 1992 as Table 1 shows. Table 1 shows that the reserves of the member states are integrated by order 1 (denoted by $I(1)$), except Italy. After applying the ADF unit root test to the level of the reserves(in the form of a logarithm), Holland is an $I(0)$. Accordingly, the cointegration test includes five members, Belgium, Denmark, France, Germany, and Ireland. The test statistics shown in Table 2 are estimated by using lag length 4. By using the adjusted critical value, the test fails to reject the null hypothesis of no cointegration under 5% significant level.[19]

IV. Conclusion

In summar y, Italy's case indicates that there is evidence of a violation of the intertemporal balance either prior to or at the time of the exchange rate crises. This is consistent with the hypothesis that speculators perceive evidence of a failure of the intertemporal balance as evidence of future policy change, where a likely component of that change is the exchange rate. However, evidence of non-sustainability does not generate either immediate speculative attack or policy change. Under the assumption of intertemporal balance, evidence of non-sustainable policy implies future policy change. The policy change might or might not include the exchange rate. Italy waited to change its exchange rate until the Fall of 1992.

Other members of the ERM in our study seem to be hit by a sudden crucial role in the system. The violation of the intertemporal balance in Germany signifies that the ERM is in jeopardy.

Without the support of efficient allocation of the foreign reserves within the member states, the ERM lose the grounds for fixing their parities. Furthermore, without sound fundamentals and with limited adjustment allowed for the member states, the ERM is doomed to be fragile.

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