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Developing an Early Warning System for Currency Crises: The Case of Jordan 1984-2008

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Abstract
Jordan economy has experienced a noticeable decline in his currency in late 1980s. Whether this decline in Jordanian dinar exchange rate is likely to endure and what kind of policies need to be followed to ensure its stability, however, still continue to be questions of considerable policy relevance. This study aims at investigating the leading indicators associated with the start of currency crisis in Jordan between 1989 and 1991. The paper employs two standard empirical methods of researching and forecasting a currency crisis: The signaling method and the Logit method to estimate the contribution of the key factors to currency crisis. The empirical results suggest that sharp decline in international reserves, decline in the trade balance, increase the broad money supply (M2), and finally the increase in the Dinar exchange rate raises the probability of currency crisis in Jordan. The finding also indicate that the four variables were identified as key to the warning system; they were succeeded and precisely warning system showed also a behavior and a precise description for the period preceding the currency crisis that occurred in Jordan.

Key words: Early warning system; Currency crises; Crisis prediction; Signal approach; Logit

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INTRODUCTION
The basic idea of the early warning system (EWS) is to monitor key economic variables which would enable policymakers to predict a crisis, allowing them sufficient time to implement the appropriate measures to stem the crisis or at the very least minimize its adverse impact through a careful look at the behavior of specific economic variables.

Since the break out of the various currency crises in 1980s and 1990s, there have been several attempts devoted to the construction of an early warning system for predicting the probability of the next crisis in order to avoid its recurrence. The Jordan currency crises in 1989, the European currency crises in 1992, the Mexican peso crisis in 1994, the Asian currency crises in 1997-1998, and the Russian currency crisis in 1998 were indeed telling, as was the devastation resulting from the Argentine crisis in 2002. In order to prevent or at least to manage better such damage to the economy, finding an effective early warning system has become an important issue of the currency crises.

The outline of this study is as follows: Section two contains a brief review of currency crises and early warning system, section three discusses the econometric methodology, the definition of currency crisis, constructs the early warning system for currency crisis, definition of a crisis, definition of the term early" for currency crises, picks out a list of potential early warning indicators, finds the optimal threshold for each indicator, and finally identify the methods of prediction. Section four contains empirical results of currency crisis in Jordan, exchange market pressure index analysis, signal approach analysis, leading time of the leading indicators, and Logit model analysis. And finally section five presents the conclusions.

1. LITERATURE REVIEW

The first formal model of a currency crisis presented by Krugman (1979), A Model of Balance-of-Payments Crises, provides the basic, intuitive insight into the first generation models of currency crises. Krugman claims that a currency crisis is caused by a large budget deficit that is financed by credit expansion. In their study Kaminsky et al. (1998), a currency crisis is defined to occur when a weighted average of monthly percentage nominal depreciations (either with respect to the US dollar or the Deutsche mark) and monthly percentage declines in reserves exceeds its mean by more than three standard deviations for that country. Frankel and Rose (1996), estimate the probability of crisis in an annual sample of 105 developing countries covering 1971–92. A crisis is defined as a depreciation of at least 25%, exceeding the previous year's depreciation by at least 10%. Berg and Pattillo (1998), they use a probit model to study currency crises. In their regression model, not only the crises themselves are labeled "one", but also the 23 months prior to the crisis. They investigate whether a threshold value for the explanatory variables, as in the signals approach, improves on a linear specification. Mishkin (2000) examines the question "what are the financial policies which help make crises less likely in emerging market countries?" Also the study reviews the financial crises that struck Mexico in 1994, East Asia in 1997, Russia in 1998 and Ecuador in 1999. The study came up with the following findings: a) There are four factors that lead to an increase in asymmetric information problems and thus to financial crisis: Deterioration of financial sector balance sheets; increase in interest rate; increases in uncertainty and deterioration of non-financial balance sheets to changes in asset prices; b) there are certain obvious links between a financial crisis and a currency crisis; the direct effect of currency devaluation on the balance sheet of firms; the devaluation of currency increases the debt burden of domestic firms, which was denominated in foreign currency as was the case of Mexico and Indonesia; c) devaluation of domestic currency leads to further deterioration in the balance sheets of the financial sector, provoking a large-scale banking crisis, as was the case in Mexico. Ivo Krznar (2004), Currency Crisis: Theory and Practice with Application to Croatia, the paper presents an early warning system of a currency crisis in Croatia, based on the signaling method and the probit model. The main findings that standing behind the currency cries are the real exchange rate appreciation that is below the trend, a decrease in the share of the balance of public finances in GDP, a decrease in the share of the current account balance of the balance of payments in GDP, an increase in inflation, and an increase in external debt, which increase the probability of a currency crisis.

2. METHODOLOGY AND DATA SET

The sample period in this study span from the first quarter of 1984 up to the fourth quarter of 2008, according to Eichengreen et al. (1994, 1996), currency crisis can be measured through the EMP (Exchange Market Pressure) index, which is calculated as follow.

$$EMP_{i,t} = \alpha\%\Delta e_{i,t} + \beta\%\Delta(i_{i,t} - i_{usai_{i,t}}) - \varphi\%\Delta r_{i,t} \qquad (1)$$

where $\%\Delta e_{i,t}$ is the deflation rate of nominal exchange rate of country i at time t, $\%\Delta(i_{i,t}-i_{usai_{i,t}})$ is the difference of interest rate between country i and United State of America, $\%\Delta r_{i,t}$ is the change rate of foreign reserve, α, β, φ are the weights to make sure that the variances are equal among these three parts. Kaminsky et al (1998), Kaminsky (1998), Kaminsky and Reinhart (1999) and Goldstein et al. (2000) followed the concept of Eichengreen et al. (1994, 1996) fairly closely, but they excluded interest rate differentials in their index and comparisons to a reference country. Kaminsky and Reinhart (1999) modified this formula as follows.

$$EMP_{i,t} = (\Delta e/e) - (\sigma_e/\sigma_R)(\Delta R/R) \qquad (2)$$

Where Δ e/e is the rate of change of exchange rate, ΔR/R is the rate of change of foreign reserves, σ_e is the standard deviation of Δe/e, and σ_R is the standard deviation of ΔR/R.

The reason for removing the interest rate is that some countries adopt interest rate control which forces this variable to have no significant explanatory role in the currency crisis.

The function of $\sigma e/\sigma_R$ is similar to the function of α, β, φ to make the variances of each part equal. Furthermore, the index was constructed separately for low and high inflation periods in order to avoid the problem that currency crises are associated with high inflation, where the latter is defined as the collection of months for which inflation in the previous 6 months was greater than 150%.

However, a major drawback of this approach is that the weights, as well as the threshold value used to identify the speculative attack, are somewhat arbitrary. Kaminsky et al. (1998), for example, define crises as periods in which the Exchange Market Pressure index is at least three standard deviations above the mean, while in Edison (2000) a crisis is detected as soon as the index is above its mean by more than 2.5 standard deviations. To make a fair comparison, we will adopt the same classification as Kaminsky and Reinhart (1999). The currency crises are defined as the situation when the observed EMP is greater than 3 standard deviations, otherwise no currency crisis is said to have happened. A currency crisis can then be defined as follows.

$$\text{Crisis}_{i,t} = 1 \text{ if } EMP_{i,t} > 3\sigma EMP_i + \mu\, EMP_i$$
$$= 0 \text{ otherwise} \qquad (3)$$

Where μEMP_i and σEMP_i are going to be calculated based on the in-sample data, and used to define the crisis for both the in-sample and out-of-sample data.

As mentioned earlier in this paper, the basic idea of the EWS is monitor the evolution of a number of economic variables. When one of these variables deviates from its "normal" level beyond a certain "threshold" value, this is taken as a warning signal about a possible currency crisis within a specific period of time. This specific period of time is called "early".

Kaminsky and Reinhart (1999) define the term early for currency crisis as between one month and twenty-four months before the beginning of the crisis. Thus, a signal that is followed by a crisis within that interval of time is called a good early warning signal, while a signal not followed by a crisis within that interval of time is called a false early warning signal, or noise.

A commonly used approach involves comparing the behavior of a set of macroeconomic variables before a crisis with that during tranquil times. One of the possible variations of this methodology is to monitor the stylized facts in the period preceding the currency crisis. The pre-crisis behavior of a variable is compared to its behavior during non-crisis periods for the same group of countries or for the group of countries where no crisis occurred. The aim is to find variables that display anomalous performance before a crisis but do not provide false signals predicting crisis, which will never happen (see WEO, 1998, p. 126; Tomczyńska, 2000).

Kaminsky, Lizondo and Reinhart (1998) presented a very detailed overview of such indicators. Any signal identified within the 24-months window before the crisis was considered as a good one, while any signal outside that period was regarded as a false alarm. The leading indicators were grouped into the following broad categories: Domestic macroeconomic variables; (2) External sector variables; (3) Public finance; (4) Global variables; (5) Institutional and structural variables. After the additional selection based on other empirical studies, authors came to conclusions summarized in Table 1. It shows the number of studies, in which any particular indicator was considered and results were statistically significant.

Table 1
Early Warnings Indicator (Statistically Significant)

Sector	Variable	Number of studies considered	Statistically significant results
Monetary Policy	International reserves	12	11
	M2/int. Reserves	3	3
	real exchange rate	14	12
	inflation	5	5
	money	3	2
	money multiplier	1	1
	credit growth	7	5
	central bank credit to banks	1	1
	real interest rates	1	1
Fiscal Policy	fiscal deficit	5	3
	government consumption	1	1
	credit to public sector	3	3
Real Sector	real GDP growth or level	9	5
	employment/unemployment	3	2
External Sector	trade balance	3	2
	exports	3	2
	terms of trade	3	2
Global Variables	Foreign interest rates	4	2
	Domestic-foreign interest rate differential	2	1
	foreign real GDP growth	2	1
Institutional and Structural	banking crisis	1	1
	financial liberalization	2	1
	openness	1	1
	crisis elsewhere	1	1

Source: Tomczyńska (2000) following analyzes of Kaminsky, Lizondo, Reinhart (1998).

The above results were partly confirmed by the cross-country empirical analyzes carried out by the members of the CASE research team. Sasin (2001a) examined the panel of 46 developed and developing countries for the period of 1990s. The special attention was devoted to distinction between variables emphasized by the first-generation and second-generation models, including multiple equilibria and contagion effect. Considerable amount of predictability was found in respect to such «classical» indicators as overvaluation of a real exchange rate and the level of central bank's international reserves. Multiple equilibria did not get much support from the investigated data while contagion, through various channels, was clearly present.

Find an optimal threshold for each indicator that, once reached, is going to give us an accurate signal of a future crisis. In other words, that threshold cuts tranquil periods from crisis periods. So an indicator is said to issue a signal whenever it departs from its mean beyond a given threshold value, usually the threshold value can be located between the tenth percentile and the twentieth percentile (Kaminsky, Lizondo and Reinhart, 1998) or between the first percentile and the twentieth percentile (Goldstein, Kaminsky, & Reinhart, 2000). In this paper we will adopt the former method.

2.1 Signal Approach

The basic idea of this approach is that the economy behaves differently on the eve of currency crises as compared with a more relatively 'normal' period. Furthermore, this aberrant behavior seems to have a recurrent systemic pattern. For example, currency crises are usually preceded by an overvaluation of the currency; banking crises tend to follow sharp declines in asset prices. Let A and B represent respectively the number of times we observe a signal when there is really a crisis and no crisis in 24 months. Let C and D represent respectively the number of times without signaling when there is really a crisis about to happen and no crisis during 24 months. A and D are the correct predictions, but B and C are the wrong predictions. We call B the false alarm. Let ω = [B/ (B+D)]/ [A/ (A+C)], where B/ (B+D) represents the wrong prediction rate when there is no crisis, and A/ (A+C) represents the correct prediction rate when there is a crisis. ω is called noise-to-signal ratio. The signal approach is given diagnostic and predictive content by specifying what is meant by an "early warning, by defining an "optimal threshold" for each indicator, and is decided by minimizing the ratio ω. Usually the threshold value can be located between the tenth percentile and the twentieth percentile (Kaminsky, Lizondo and Reinhart, 1998) or between the first percentile and the twentieth percentile (Goldstein, Kaminsky, and Reinhart, 2000). In this paper we will adopt the former method.

Table 2
Contingency Table of the Crisis

	Crisis	No crisis
Signaling	A	B
No signal	C	D

Source: Kaminsky, Lizondo and Reinhart, 1998.

2.2 Logistic Approach

Since the dependent variable, currency crisis, is a binary variable from a qualitative point of view, the logistic regression model is also seemingly a good candidate (Baltagi, 1995). Let Y_{it}=1 represent that country *i* has a crisis at time t, and Y_{it}=0 otherwise. Let P_{it} indicate the probability of country *i* to have a crisis at time t, then

$$E(Y_{it})=1\times P_{it}+0(1-P_{it})=P_{it} \quad (4)$$

which can be expanded by including n explanatory variables and can be written as the following equation.

$$P_{it}=P_r(Y_{it}=1)=\mathrm{E}(Y_{it}|\,\mathrm{X})=F'(\beta' X_{it}) \quad (5)$$

$$Y^*_{it}=\beta' X_{it}+\varepsilon_{it} \quad (6)$$

where Y^*_{it} is the actual dependent variable which cannot be observed, and X_{it} is the vector consisting of n explanatory variables, β′ is the vector consisting of n unknown coefficients, ε*it* is the error term. Then the log-likelihood function can be written as follows.

$$\log L\sum_{t=1}^{T}\sum_{i=1}^{I}\{P_{it}\ln[F(\beta' X_{it})]+(1-P_{it})\ln[1-F(\beta' X_{it})]\} \quad (7)$$

Where *T* is the number of periods, the parameters can be obtained through the maximum likelihood method (Gujarati, 2003).

3. EMPIRICAL RESULTS

The empirical part of this paper can be divided into three parts; the first one exhibits the results of the early warning system developed in this paper to predict the currency crisis in Jordan using the Exchange Market Pressure index (EMP), The second part shows the results of the leading indicators of a currency crisis in Jordan by employing the signal approach, and the third part seeks to explore the relation between the leading indicators and the currency crisis in Jordan and to indicate the contributions of the these indicators in triggering a currency crisis in future by running the logit model against the dependent variable which is the currency crisis expressed as "crisis" in the following analysis.

3.1 Exchange Market Pressure Index Analysis

Based on what we have already explained in section three we calculated the EMP according to equation (2) over the whole period of the study. Then we used the results of this equation to predict the currency crisis in Jordan according to equation (3), then we applied the calculations for the in-sample period of the study which extended from 1984Q2-2008Q4, the findings confirmed that Jordan had two currency crises in this period, one was in December 1988, and the other one in March 1989, which is agreed with what Jordan have in the reality, see Table 3. In order to assess the predicting power of the early warning system developed in this study, we simulated the crisis that Jordan had in 1988-89; by proposing a shock of the same declined ratios in an out-of-sample extended from 2007Q1-2008Q, for both of the nominal exchange.

GREX: Growth rate of nominal exchange rate. RES: Gross international reserves. GRES: Growth rate of gross international reserves, EMP: exchange market pressure, μ + 3σ: Threshold rate of JD, and to the gross international reserves. As shown in Table 3, the results did confirm that the predicting power of the early warning system for the out-of-sample period2007:Q1-2008Q3, as shown for

the in-sample period 1984:Q1-2006Q4. And exhibited that if the nominal exchange rate of JD, and the gross international reserves declined by the same ratios that happened in 1988 (column 2, and column 4 of Table 3) respectively, then the early warning system signaled that we will have two currency crises, the first one in September 2007, and the second in march 2008, which is consistent with the spirit of an "early warning system", and fulfill the first and the second hypotheses which implied that the early warning system can predict the currency crisis in-sample and out-of-sample as well.

Table 3
The Growth Rate of Nominal Exchange Rate of JD/$US and the Gross Internal Reserves During 1988-1989

Quarter	Nominal exchange rate JD/$US (e.o.p) (1)	GNEX (2)	RES (3)	GRES (4)	EMP (5)	μ + 3σ (6)	Crisis (7)
1988 Q1	-	-	-	-	-	-	-
1988 Q2	.335	0.089	287.462	-0.045	0.094	0.141	0
1988 Q3	.365	0.037	274.504	0.158	0.018	0.141	0
1988 Q4	.378	0.260	318.137	-0.021	0.263	0.141	1
1989 Q1	.477	0.132	311.215	-0.651	0.213	0.141	1
1989 Q2	.54	0.052	108.361	0.397	0.003	0.141	0
1989 Q3	.568	0.082	151.445	1.36	-0.086	0.141	0
1989 Q4	.615	0.053	357.495	-0.071	0.062	0.141	0

Source: Authors calculations.

Table 4
The Nominal Exchange Rate of JD/$US and the Gross Internal Reserves During Out-of-Sample (2007-2008) **Shock**

Quarter	NEXR JD/$US	SNEXR	GSNEX	RES	SRES	GSRE	GRES	SEMP	Sμ + S3σ	SCRISIS
2007 Q1	.709	.646	0.057	4536.3	3815.245	0.191	-0.019	0.040	0.21879	0
2007 Q2	.709	.682	-0.232	4446.4	4543.144	0.737	0.074	-0.294	0.21879	0
2007 Q3	.709	.524	0.174	4778.4	7893.024	-0.628	0.019	0.228	0.21879	1
2007 Q4	.709	.615	0.092	4871.4	2934.546	-1.472	-0.21	0.217	0.21879	0
2008 Q1	.709	.672	-0.032	3844.5	-1386.17	-4.612	0.215	0.360	0.21879	1
2008 Q2	.709	.651	0.031	4674.3	5006.736	0.338	0.168	0.003	0.21879	0
2008 Q3	.709	.671	0.019	5462.6	6698.565	-0.425	0.005	0.055	0.21879	0

Source: Authors calculations.

SNEXR: Shocked Nominal Exchange Rate JD/$US, GSREX: Growth rate of shocked nominal exchange rate SRES: shocked gross international reserves. GSRES: Growth rate of shocked gross international reserves, EMP: Shocked exchange market pressure, sμ + s3σ: Shocked threshold, SCRISIS: the shocked crisis.

3.2 Signal Approach Analysis

After having known that the EMP was able to predict the currency crisis, we employed this result in the signal approach to check if it is able as well to determine the leading indicators of a currency crisis that give signals during the signalling window before the onset of a crisis or not. The effectiveness of the signals approach can be examined at the level of individual indicators and at the level of set of indicators. The discussion below examines the effectiveness of individual indicators. It applies the analysis presented in section 3, by ranking the various indicators according to their forecasting ability, and by examining the lead time. In order to examine the effectiveness of individual indicators, it would be useful to consider the performance of each indicator in terms of the following matrix:

	Crisis (Within 24 months)	**No crisis** (Within 24 months)
Signal was issued	A	B
No signal was issued	C	D

In this matrix, A is the number of months in which the indicator issued a good signal, B is the number of months in which the indicator issued bad signal or "noise", C is the number of months in which the indicator failed to issue a signal (which would have been a good signal), and D is the number of months in which the indicator refrained from issuing a signal (which would have been a bad signal). A perfect indicator would only produce observations that belong to north-west and south-east cells of this matrix (A, D). It would issue a signal in every month that is to be followed by a crisis (within the next 24 months), so that A > 0 and C = 0, and it would refrain from issuing a signal in every month that is not to be followed by a crisis (within the next 24 months), so that B=0 and D > 0, of course, in practice, none of the indicators fit the profile of a perfect indicator. However, the matrix above will be useful reference to assess how close or how far is each indicator from that profile.

Information on performance of individual indicators is presented in Table 5. For each indicator, the first column shows the percentage of crises correctly called, defined as the number of crises for which the indicator issued at least one signal in previous 24 months (expressed as a percentage of the total number of crises for which data on the indicator are available). Virtually every indicator called correctly at least half of the crises in their respective samples. On average, the various indicators called correctly 70 percent of crises.

The second column of Table 5 shows an alternative measure of the tendency of individual indicators to issue good signals. It shows that the number of good signals issued by the indicator, expressed as a percentage of the number of months in which good signals could have been issued (A/(A+C) in terms of the above matrix). While obtaining 100 percent in the second column of Table 5 would require that at least one signal be issued within 24 months prior to each crisis, a 100 percent in the second column would require that a signal be issued every month during the 24 months prior to each crisis. In terms of the results in the second column, the Political Stability is the indicator that issued the highest percentage of possible good signals (25 percent), while real GDP issued the lowest percentage of possible good signals (2 percent) sending bad signals. It shows the number of bad signals issued by the indicator, expressed as a percentage of the number of the months in which bad signals could have been issued (B/ (B+D) in terms of the above matrix). Other things equal, the lower the number in this column is, the better the indicator. The Political Stability, once again, shows the best performance (issuing 6 percent of possible bad signals), while the Current Account Balance shows the poorest performance (issuing 81 percent of possible bad signals). The information about the indicators' ability to issue good signals and to avoid bad signals can be combined into a measure of the "noisiness" of the indicators. The fourth column of Table 5 shows the "adjusted "noise-to-signal ratio; this is obtained by dividing false signals measured as a proportion of months in which false signals could have been issued, by good signals measured as a proportion of months in which signals could have been issued ([B/ (B+D)]/ [A/ (A+C)] in terms of the a above matrix). Other things equal, the lower the number in this column, the better the indicator.

The various indicators differ significantly with respect to their adjusted NTS ratios. While this ratio is only 0.06 for the Political Stability (followed by fiscal deficit at .33), it is 1.3 for the Real GDP. The adjusted NTS ratio can be used as a criterion for deciding which indicators to drop from the list of possible indicators. A signaling device that issues signals at random times (and thus has no intrinsic predictive power) would obtain (with a sufficiently large sample) an adjusted NTS ratio equal to unity. Therefore, those indicators with an adjusted NTS ratio equal to or higher than unity introduce excessive noise, and so are not helpful in predicting crises. Thus, on the basis of the results presented in Table 5, there is one indicator that should be removed from the list of those to be used within the signal approach, which is the real GDP indicator. These findings agreed with that of kaminsky et.al especially for some of the common leading indicators used in both studies, such as the ratio of broad money supply (M2) to international reserves, in their study the ratio was 0.42 while in ours was 0.42, and for exports was 0.45 in our paper, whereas, it was 0.42 in their paper, see Table 5 for the rest of indicators.

Table 5
Performance of Indicators Under the Signal Approach

	Percentage of crises called (1)	**Good signals as percentage of possible good signals** (2)	**Bad signals as percentage of possible bad signals** (3)	**Noise/signal (adjusted)** (4)
In terms of the matrix in the text		A/(A+C)	B/(B+D)	[B/(B+D)/ A/(A+C)]
Political Stability	25	100	6	0.06
Fiscal Deficit	9	33	11	0.33
Inflation	14	100	36	0.36
Money supply (M2)	10	75	32	0.42
Exports	21	77	35	0.45
Employment	14	66	30	0.45
Openness	18	100	48	0.48
Terms of Trade	20	75	39	0.52
Trade Balance	10	80	43	0.53
Domestic credit	9	60	36	0.60
Real Exchange Rate	10	100	65	0.65
Real Effective Exchange Rate	13	50	36	0.72
Current Account Balance	10	100	81	0.81
M2/International Reserves	7	66	58	0.87
International reserves	9	66	60	0.90
Real GDP	2	33	43	1.3

Source: Authors calculations.

Column (1): Shows the percentage of crises correctly called, defined as the number of crises for which the indicator issued at least one signal in previous 24 months. Column (2): Shows that the number of good signals issued by the indicator, expressed as a percentage of the number of months in which good signals could have been issued Column (3): Shows the number of bad signals issued by the indicator, expressed as a percentage of the number of the months in which bad signals could have been issued Column (4): Shows the noise to signal ratio Columon3/column 2

4 LEADING TIME OF THE LEADING INDICATORS

The previous discussion has ranked the indicators according to their ability to predict crises while producing few false alarms. However, such criteria are silent as to the lead time of the signal. From the vantage point of a policymaker who wants to implement preemptive measures, he/she will not be indifferent between an indicator that sends signals well before the crisis occurs and one that signals only when the crisis is imminent. In focusing on the 24-month window prior to the onset of the crisis, the criteria for ranking The indicators presented in Table 5 do not distinguish between a signal given 12 months prior to the crisis and one given one month prior to the crisis.

To examine this issue, we tabulated for each of the indicators considered the average number of months in advance of the crisis when the *first* signal occurs; this, of course, does not preclude the fact that the indicator may continue to give signals through the entire period immediately preceding the crisis. Table 6 presents the results. Indeed, the most striking fact about these results is that, on average, all the indicators send the first signal anywhere between half a year and two years before the crisis erupts, with openness and terms of trade sector (which reflects the external sector indicator) offering the longest lead time. Hence, on this basis, all the indicators considered are leading rather than coincident except the fiscal deficit and real GDP, which is consistent with the spirit of an early warning system.

Table 6
Average Lead Time

Indicator	Number of months in advance of the crisis when first signal occur
Openness	24
Terms of Trade	24
Exports	21
Current Account Balance	21
Real Exchange Rate	18
M2/International Reserves	18
Money supply (M2)	18
Real interest rate	15
Inflation	12
Employment	12
Trade Balance	12
International reserves	12
Real Effective Exchange Rate	9
Domestic credit	9
Political Stability	6
Fiscal Deficit	-
Real GDP	-

Source: Authors calculations.

The findings above relatively closed again to some other studies like that of kaminsky et.al especially for some of the common leading indicators used in both studies.

5. LOGIT MODEL ANALYSIS

Exploring the relationship between currency crisis and potential variables that may trigger currency crisis in Jordan require estimating logit model as mentioned in subsection 3-6-2 of section three. But, before moving to this step, let us have a look at the characteristics of the data used in running the model, Table 7 below shown the summary statistics.

Table 7
Summary Statistics

	GOREX	CRISIS	GRES	GOFD	GORGDP	GOTB	GOPENES
Mean	0.003939	0.373737	0.061717	1.217475	0.011111	0.045455	0.003293
Median	0.000000	0.000000	0.020000	-0.880000	0.010000	0.030000	0.004000
Maximum	0.160000	1.000000	1.360000	135.7200	0.120000	0.870000	0.216000
Minimum	-0.080000	0.000000	-0.650000	-34.10000	-0.120000	-0.500000	-0.190000
Std. Dev.	0.032758	0.486257	0.260161	16.06384	0.056168	0.241286	0.073132
Skewness	0.905640	0.521967	1.874499	6.362295	-0.101385	0.438638	0.432461
Kurtosis	7.943182	1.272450	11.53005	52.35749	2.457945	3.754409	3.417963
Jarque-Bera	114.3276	16.80619	358.1189	10717.07	1.381622	5.522328	3.806483
Probability	0.000000	0.000224	0.000000	0.000000	0.501170	0.063218	0.149085
ADF	-5.999345*	-6.70110*	-507487*1	-6.043321*	-12.56432*	-8.909689*	-9.253695*
Sum	0.390000	37.00000	6.110000	120.5300	1.100000	4.500000	0.326000
Sum Sq. Dev.	0.105164	23.17172	6.633008	25288.61	0.309178	5.705455	0.524133
Observations	99	99	99	99	99	99	99

Source: Authors calculations.
NOTES: * is significant at 1% levels.

In order to have large sample for the estimation of a currency crisis in Jordan, the paper is based on a quarterly data over the period 1984:01–2008:3. The statistics in the Table 8 shows based on Jarque-Bera that we can reject the null hypothesis of normal distribution. Kurtosis shows that the probability density function (PDF) for growth rate of openness (GOPENES), growth rate of trade balance (GOTB), growth rate of fiscal deficit (GOFD), the growth rate of gross international reserves GRES), and the growth rate of real exchange rate (GOREX) is greater than three which mean it is leptokurtic (slim or long tailed). Also, the skewness shows the PDF lacks of symmetry and it has a long right tail [The normal distribution has the following features skewness = 0, Kurtosis = 3, Jarque-Bera = 0.].

The estimation of Logit model, equation (7) produces statistically significant and economically intuitive results. Table 8 reveals the results of predicting currency crisis by using the Logit model.

The results demonstrate that: The relation between the probability of a currency crisis and the growth rate of gross international reserve (GRES) in Jordan is negative and statistically highly significant, the relation between the probability of a currency crisis and the growth rate of real exchange rate (GOREX) in Jordan is positive. That is, increasing the growth rate of real exchange rate (GOREX), will lead to an increasing in the probability of a currency crisis in Jordan, the relation between growth rate of trade balance (GOTB) and the currency crisis is also negative, i.e. an increase in the growth rate of trade balance will decrease the probability of currency crisis, while the opposite will increase the probability. The relationship of the broad money supply (GOM2) with probability of currency crisis is strongly positive, i.e., if the growth rate of M2 increased the probability of currency crisis will increase, while if it decreased the probability of crisis will increased as well.

To predict the probability of currency crisis, that logistic regression has been performed on gross international reserve, real exchange rate, trade balance, and broad money supply (M2); the estimates obtained from the logistic regression analysis are shown in Table 8.

Table 8
Summary of Logit Regression Analysis

Leading indicators	Coefficient	Std. error	Prob.
C	-0.992363	0.48[1]385	0.1743
(GRES)	-23.41807	5.261939	0.0393
(GOREX)	29.93375	13.41899	0.0000
(GOTB)	-3.851982	1.885555	0.0257
(GOM2)	38.87957	16.87712	0.0411

Source: Authors calculations.

So the estimate of c is -0.9923, of gross international reserves is -23.4, of real exchange rate is 29.9, of trade balance is -3.8, and of broad money supply (M2) is 38.8, the odds of currency crisis are less if the Jordan economy has a high gross international reserves, high trade balance, low money supply, and low exchange rate.

The equation of the Ln (odds), or logit, is estimated by:

Ln (odds) = -0.9923- 0.23(GRES) + 0.29(GOREX) – 0.03(GOTB) + 0.38(GOM2)

The interpretation of these coefficients is as mentioned above. Where the dependent variable (currency crisis) is: Ln (P_Z/1-P_Z) and P_Z is the logistic regression equation, estimated as:

$$\text{Prob (currency crisis)} = \frac{\exp\{-0.9923 - 0.23(GRES) + 0.29(GOREX) - 0.03(GOTB) + 0.38(GOM2)\}}{1 + \exp\{-0.9923 - 0.23(GRES) + 0.29(GOREX) - 0.03(GOTB) + 0.38(GOM2}$$

For the continuous variables as we have here in this paper, with slope coefficients, the quantity exp (b) is interpreted as the ratio of the odds for the Jordan economy with value X+1 relative to the odds for the Jordan economy with value X. Therefore, exp (b) is the incremental odds ratio corresponding to an increase of one percent in the variables in our paper, assuming that the values of all others X variables remain unchanged.

The probability of currency crisis in Jordan according to the above illustration is shown in Table 9, the probability increased or decreased according to the relation between the currency crisis and the variable included.

Table 9
The Estimates of the Probability of Currency Crisis

Leading indicators	**Prob** (currency crisis)
(GRES)	0.226829668
(GOREX)	0.333374264
(GOTB)	0.262925161
(GOM2)	0.353542444

Source: Authors calculations.

CONCLUSION

Based on what we have already explained in this paper, the first finding confirmed that Jordan had two currency crises, one was in December 1988, and the other in March 1989, which is agreed with what Jordan have in the reality. If the nominal exchange rate of JD, and the gross international reserves declined by the same ratios that happened in 1988-1989, then the early warning system would signal two currency crises, the first one in September 2007, and the second in march 2008, which is consistent with the spirit of an early warning system.

Using a signals approach, the set of leading indicators proved to be useful in predicting previous episodes of currency crisis in Jordan. Every indicator called correctly at least half of the crises in their respective samples. On average, the various indicators called correctly 70 percent of crises. The Political Stability is the indicator

that issued the highest percentage of possible good signals (25 percent), while real GDP issued the lowest percentage of possible good signals (2 percent). Measures the performance of individual indicator regarding sending bad signals, the lower the number is, the better the indicator. The Political Stability, once again, shows the best performance (issuing 6 percent of possible bad signals), while the Current Account Balance shows the poorest performance (issuing 81 percent of possible bad signals). The most striking fact about leading time of the leading indicator, was on average, all indicators send the first signal anywhere between half a year and two years before the crisis erupts, with openness and terms of trade (which reflect the external sector indicators) offering the longest lead time. Hence, on this basis, all the indicators considered are leading rather than coincident except the fiscal deficit and real GDP, which is consistent with the spirit of an early warning system. The relation between the probability of a currency crisis and the growth rate of gross international reserve in Jordan is negative and statistically highly significant, the relation between the probability of a currency crisis and the growth rate of real exchange rate in Jordan is positive. That is, increasing the growth rate of real exchange rate, will lead to an increasing in the probability of a currency crisis in Jordan, the relation between growth rate of trade balance and the currency crisis is also negative, i.e., an increase in the growth rate of trade balance will decrease the probability of currency crisis, while the opposite will increase the probability, and the relation of the broad money supply with probability of currency crisis is strongly positive, i.e., if the growth rate of M2 increased the probability of currency crisis will increase, while if it decreased the probability of crisis will increased as well.

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