AN EARLY WARNING SYSTEM FOR CURRENCY CRISIS

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ABSTRACT

This paper constructs a standardized index of speculative pressure (SISP) for Jordan to predict a currency crisis. The basic idea behind signal approach is that the behavior of mainly macroeconomic factors changed before a currency crisis from that of tranquil periods. The performance of standardized ISP is conducted and if a certain threshold value of 1.25 standard deviations is crossed during the signaling period of eight quarters, it is judged as a warning of possible currency crisis. The major findings of this study is that Jordan standardized ISP produced an excellent signal preceding the crisis of 1988/1989. Also, the standardized ISP shows that currency crisis is not to be expected for the next two years, 2016 and 2017

Keywords: *Financial Crises, Financial Econometrics, Model Evaluation, Validation, and Selection, Forecasting and Simulation*

INTRODUCTION:

The purpose of this study is to develop an early warning system (EWS) based on a signal approach indicators to calculate the risk of potential currency crises in Jordan. Currency crisis is also known as a balance of payments crisis where the value of a currency depreciates significantly and quickly. Therefore, it undermines the ability of the currency to serve as a store of value or a medium of exchange for a period of time. Currency crises usually go together with speculative attack on the currency. The term financial crisis is a situation in which assets or financial institutions abruptly lose a significant percentage of their value. This could be the result of banking panics, stock market crashes, currency crises, or sovereign defaults. Central bank usually increases interest rate and buys their own currency, using the country's foreign reserves, when a country faces a currency crisis. A currency crisis is considered to occur when speculative attack, successful or unsuccessful, on the currency lead to steep devaluation of a currency, a huge decline in foreign reserves, or a combination of both. If a depreciation of a currency exceeds a threshold, the depreciation should be labeled a crisis. The unsuccessful speculative attack that leads to depletion of large percentage of foreign reserves should be considered a crisis. Major economic fluctuation causes distress to an economy. The foreign reserve losses may prevent currency crises, but it generates negative economic consequences on employment and growth potential.

The EWS of currency crisis is based on the concept that some indicators (variables) may exhibit unusual behaviors (signals) prior to currency crisis. An indicator is believed to send a signal that a currency crisis may happen whenever the value of an indicator falls or exceeds a given threshold (Ari & Gergibozan, 2018).

Under a fixed exchange regime (as the case of Jordan dinar visa vie the US dollar since 1995) an increase in interest rate in the US would increase interest rate in Jordan, and consequently reduce GDP. The decline of GDP would make it costly for Jordan to maintain fixed exchange rate regime. Once the rate of interest reached a high level, then the cost of maintaining fixed exchange regime may exceeds the benefits especially if cost of government debt is large, then the country would abandon fixed exchange rate regime. Therefore, the GDP, domestic interest rate, and foreign interest rates could be useful indicators of currency crisis. The abandon fixed exchange rate regime may not depend on the size of debt alone, but also on the balance sheet of the banking system. If an increase in interest

rate weakens the banking system, then the cost of bailing out the banking system may exceeds the cost of abandoning the fixed exchange rate regime. Therefore, problem with balance sheet of the banking system could be an indicator of potential currency crisis. Weakness in the balance sheet of the banking system could be the result of high percentage of non-performing loans, large decline in deposit, or the amount of credit given to commercial banks by the central bank.

Also, devaluation in the currency of a country's major trading partner may lead the country to devalue its currency in order for the country to keep its comparative advantage and avoid balance of payment crisis. The above process is called contagion effect where the existing crisis in the country's major trading partner may be an indicator of potential domestic currency crisis. According to Warburton (2014) financial crisis reduces liquidity, decrease credit accessibility, and harms investors and household confidence in the economy.

The paper is organized as follows. Section 2 presents the importance of building an EWS and highlights the theoretical development. Section 3 reviews previous literature on Currency crises. Section 4 outlines the methodology for building an early warning system and the choice of indicators. Section 5 discuss the evaluation criteria and analysis while the last section is a conclusion.

The Importance of Building an EWS

Building an EWS is very helpful for government decision-makers and consequently for the welfare of society if one could predict accurately with sufficient advance, in terms of time, to allow government to adopt policies and measures to avoid or mitigate a currency crisis. An EWS should use a wide range of indicators because currency crisis usually comes after multiple economic, and sometimes political, problems.

The cost of currency crisis for a developing country is expensive not only for the country itself, but sometimes to other countries. The high cost because the size of international trade and capital flows are large relative to the local economy. The enormous economic losses of currency crisis lead policy makers to search for tools to identify early weaknesses and use policies to avoid crises from happening beforehand. The consequences of financial crisis are a long recession, deflation, and adverse fiscal problem.

The EWS gives market participants, as well as policy-makers, a warning that a crisis is expected to happen. The EWSs are not without faults, but are useful in synthesizing information, provide incremental knowledge about the country, and provide a mechanism to improve the detection of future crisis. A currency crisis can not be completely anticipated by a EWS.

The definition of a crisis varies from one author to the other. Some defined crisis if real exchange rate decline by 20% in a quarter, others by 20% in two weeks, and others by k standard deviations. Some used two measures to define a crisis. These two measures are a weighted average of exchange rate and foreign reserves by more than two standard deviations plus a decline of GDP growth rate by more than 3%. Usually, currency crises and banking crises tend to occur together, but banking trouble usually precedes currency crisis. For Jordan, an index of speculative pressure (ISP) will be built to anticipate currency crisis.

Theoretical Development:

The first generation models (traditional approach) were developed by Krugman (1979). The excess creation of domestic credit, weak economic fundamentals, and government fiscal deficit would lead to a depletion of foreign reserves. The timing of currency attack would be when the remaining foreign reserves before the attack are barely enough to satisfy foreign currency demand of market participants during the speculative attack. Currency crisis may not be avoided if speculators know that government is unable to borrow from capital market to increase its international reserves and monetary authority has to rely on domestic credit expansion for the banking system to recover once it is in trouble. The excessive expansion of domestic credit (money supply) reduces local interest rate and increases capital outflow and a loss of international reserves. The moment speculators are able to buy the remaining reserves, the attack on the currency will start. The speculative attack would lead to a currency crisis and force the central bank to abandon the fixed exchange rate regime. Krugman (1979) argued that depletion of foreign reserves and consequently abandoning of the fixed exchange rate (depreciation of the currency) was the result of excessive expansionary monetary and fiscal policies. The excessive expansion of domestic credit under a fixed exchange regime leads to a continuous decline of foreign reserves, collapse of fixed exchange regime, and a loss for the holders of domestic currency. The above implies that a decline of foreign reserves and the expansion of local credit precede a currency crisis. Also, if the central bank resorts to excessive expansion of money

supply to accommodate an expansion of government debt, then fiscal deficit and credit to government sector would be indicators of future currency crisis. The expansion of local credit and government deficit spending would lead to higher demand for imported goods which may cause trade imbalance and increase in wages, increase in the prices of nontradable goods and services, real appreciation of the currency, and a decline of the competitiveness of the economy. If the authority is determined to defend the fixed exchange rate, the local interest rate would increase ahead of a currency crisis. Thus, an appreciation of the exchange rate, current account deficit, an increase in real wages, and higher domestic interest rates may be used as leading indicators of currency crisis. Transitional economy is an economy that moves from being centrally-planned economy toward a free market oriented economy by removing price control, reducing trade barriers, privatizing state owned enterprises, and implementing free movement of financial capital. The 1999 Brazil financial crisis according to Barisk and Tay (2010) is balance of payments crisis and a financial crisis. Also, the financial crises that were experienced by the transitional economy of Romania in 1997/1998, Bulgaria in 1996/1997, and Hungary in 1994/1995 as well as early 1980s in Latin America are all considered first generation currency crisis.

The second generation models started with Obsfeld (1986). This model is based on selffulfilling expectations, contagion effect, and investors herd behavior (following big institutional informed investors). An example of these types of contagion effect model is the currency crisis of 1995-1995 in Latin America. The currency attack can take place even though there is no fundamental weakness of the economy or lack of sufficient foreign reserves. Speculative attack can take place because the cost of high domestic interest rate in terms of higher rate of unemployment, higher cost of public debt to defend the fixed exchange rate regime, increase banking system problems, and slower economic growth may lead to abandoning of fixed exchange rate regime. Higher interest rate increases short run cost of banking deposits, increase the probability of default on loans, and reduce profit for the banking system. Currency crisis and banking crisis could be related. If there is a government commitment to bail out failed banks, then an increase in liquidity by the government to bail out failed banks may make it difficult for the government to keep fixed exchange rate regime. The causality may be going from the other direction that is from exchange rate depreciation to banking crisis. Also, if the domestic banking is exposed to exchange rate risk, due to short term borrowing this may lead to banking crisis.

But depreciation of a currency may not be the result of depletion of foreign reserve, but as a tool to achieve lower rate of unemployment in order for the country to deal with high rate of interest. Sometimes the currency crisis may occur due to speculative attack and not because of weak economic fundamentals. In this circumstance economic policies and economic indicators are not the reason but the consequences of speculative attack. Therefore, economic participants take into account the possibility of speculative attack in forming their expectations and may lead to selffulfilling prophecy of currency crisis.

Third generation currency crisis models argued that the causes of this type of currency crisis start with difficulty in the banking system, herd behavior, and contagion effects. The unstable banking system is due to lack of inadequate supervision, moral hazard due to asymmetry of information, banks borrowing in foreign dominated currency, and implicit or explicit guarantee from government or international financial institution of foreign debt or domestic banks' debt. The currency crisis could be the result of contagion effect through trade, interdependence of financial system, and economic similarities of neighboring countries. The major leading indicators of third generation currency crisis according to Barisik and Tay (2010) are M2/international reserves, M2 growth rate, and domestic loans.

The newly industrialized country (an emerging market) is characterized by having middle income level, experienced decrease in the income gap with the industrialized countries, and integrated into the world economy. Also, the newly industrialized country experiences growth of its industry relative to other sectors of the economy and wide spread use of informational technology. According to Barisk and Tay (2010) the emerging market usually faces third generation crisis models. The financial crises of Thailand, Indonesia, Malaysia, and South Korea of 1997, and Russia in 1998 are considered third generation currency crisis.

Kaminsky and Reinhart (1999) and Taylor (2013) argued that most of the currency crises that had happened in the 1980s and 1990s were the result of an economy entering into a recession after a period of credit expansion, substantial financial capital inflows, and overvalued currency. The result was a twin crisis of concurrent collapse of banking system and a large currency devaluation. According to Taylor (2013) financial instability was part of advanced economy before 1930s. But, the improved bank regulations, reserve requirements, robust domestic financial supervision, and fixed exchange rate and deposit insurance corporations of the 1930s made the world see few financial crises

in emerging economy until early 1970s. The 1980s and 1990s financial deregulations and free international capital movements led to many financial crises in emerging markets and few in advanced economy. The 2008 financial crises swept advanced economies too.

The Empirical Literature of Currency Crises:

Kaminsky, Lizondo, and Reinhart (KLR) (1998) did an overview of the empirical studies published from 1979 until 1998; Abiad (2003) surveyed of the empirical studies from 1998 until 2003; Wu Jun (2007) did an overview of the empirical studies from 2003 until 2007; and Barisik and Tay made an analysis of financial crisis in transitional economies and emerging market for the period 1994-2006. Most of the empirical studies used monthly data and few of them focused on a single country. The indicators of currency crises are those variables that impact economic fundamentals or exchange market expectations. The indicators are selected on the basis of theoretical consideration and data availability. The signal approach is based on predicting currency crisis by an individual indicator and a group of indicators. The efficiency of an indicator or group of indicators taken jointly in predicting crisis can be ranked according to their forecasting accuracy, the lead time, and their persistent signals. The idea of signaling approach is that the behaviors of mostly economic and financial indicators before a currency crisis differ from that in tranquil periods.

Wu Jun (2007) in her study of the causes of currency crises in Asian, European, and Latin American countries found out that weak economic fundamentals (loss of international reserves), an overvalued exchange rate, or a high ratio of M2 to foreign reserves gave an early warning signals of a future currency crisis. Frankel and Rose (1996) discovered in their empirical investigation of 105 developing countries that domestic credit growth, high foreign interest rate, the overvaluation of real exchange rate, low level of foreign direct investment, and low foreign reserves were important indicators for currency crises. These indicators could be used to build an EWS for currency crisis.

KLR (1998) summarized the finding of 28 empirical studies on currency crises. They found that currency crises could have many different causes, have variety of variables to explain currency crises, and few variables seem to have the predictive power of many crises. KLR (1998) also found that real exchange rate deviation issued the highest percentage of accurate signals (that was 25% of the time) and lowest false signals.

On the other hand, imports issued the lowest percentage of accurate signals. The lower the ratio of bad signals to good signals, the better is the indicator. One has to remove the indicator from the list of indicators if the ratio of inaccurate signal to accurate signal is greater than or equal to one because it is not helpful in predicting currency crisis. KLR (1998) examined 105 variables. Forty eight of them are in the external sector (consist of 16 in the capital account, 10 in the debt profile, 19 in the current account, and four in the international); 21in the financial sector (consist of six in the financial liberalization and 15 in the other financial); nine in the real sector; six in the fiscal; 10 in the institutional/structure; nine in the political; and one is in the contagion.

KLR (1999) found that the macroeconomic variables that have the best track record and statistically significant were exports, deviation of exchange rate from trend, GDP, equity prices, and the ratio of M2 to foreign reserves. Also, they found that monitoring the behavior of foreign reserves, real exchange rate, domestic credit, credit to the public sector *(known as public debt or national debt)*, and domestic inflation are important in anticipating currency crisis. Other indicators of abnormal behavior before a crisis such as trade balance, exports, money growth, real GDP, and fiscal deficit provided supportive evidence of currency crisis. The indicators that are issuing signals would inform the decision makers about the source and the depth of the problems that trigger a crisis.

The typical response of authorities to a currency attack is raising interest rate or direct intervention in foreign exchange market or a combination of both. The failed speculative attacks lead to higher local interest rate and considerable decline in foreign reserves. The necessary policy to deal with a crisis or potential crisis could be disruptive for the economy. Unsuccessful attack on the currency is an indication of economic vulnerability. Frankel and Rose (1996) used the Probit model to estimate the probability of crisis using annual data. They found out that probability of crisis increases when output growth is low, domestic credit growth is high, foreign interest rates are high relative to domestic interest rates, foreign direct investment as a percent of total debt is low, foreign reserves are low, and the real exchange rate is overvalued. The predictions for out of sample were disappointing, especially if the crisis takes place around the end of the year. Barisik and Tay (2010) and Schulaick and Taylor (2012) used panel logit model to identify the leading indicators of currency crises of transition economies and emerging-market economies for the 19942006 period. He found that real exchange rate and percentage change in foreign reserves are the leading indicators of financial crisis in both economies. Current trade deficit and inflation are contributing to financial

crisis in transitional economy; while credit growth is a contributing factor to financial crisis in emerging market. The result of their logit model shows that domestic credit growth and the ratio of M2 to international reserves to be insignificant for transitional economy even though are important indicators for third generation crisis models. The overvalued real exchange rate reduces the competitiveness of the economy, reduces international reserves, increases imports and reduces exports.

Sachs, Tornell, and Velasco (1996) claimed that the value of three factors for the period of four years before the crisis were essential for measuring vulnerability. The first factor is average overvalued real exchange rate; the second factor is the weak banking system, measured by the growth rate of credit to the private sector; and the third factor is the low level of foreign reserves relative to M2. They conclude that the combination of the above three factors lead to a crisis. The weak fundamentals (overvaluation of real exchange or weak banks) and relatively low foreign reserves lead to a crisis.

Goldstein, Kaminsky, and Reinhart (2000) found that banking crises in emerging economies are more difficult to forecast accurately than are currency crises. This probably reflects difficulties in accurately dating banking crises and the absence of monthly or quarterly data on the institutional characteristics of national banking systems. Also, cross-country contagion adds significantly to own-country fundamentals in explaining emerging-market vulnerability to financial crises. Such contagion has operated more along regional than global lines. According to the Goldstein, Kaminsky, and Reinhart "contagion vulnerability index," Brazil, Argentina, and the Philippines had high vulnerability to the 1994 Mexican peso crisis; Malaysia, South Korea, and Indonesia had high vulnerability to the 1997 Thailand crisis; and Argentina, Chile, and Uruguay had high vulnerability to the 1999 Brazilian crisis.

Al-Assaf, (2017) investigated the differences between the number of indicators used for an early warning system to explain any potential currency crisis for the case of Jordan and Egypt. He based his investigation on estimating various leading indicators that help in predicting the currency crises in those countries. Jdaitawi (2014) used the signaling method (along with the Logit method) to estimate the contribution of key factors to currency crisis in Jordan during the late eighties. Using Jordanian data, and Multinomial Logit analysis, Al-Assaf, et al. (2013) developed an EWS to explain

any potential currency crisis and identify a number of leading indicators that can help the understanding of the crises.

Methodology for Building EWS:

There are four methods in the literature used for building EWSs. These methods are the Markov-Switching model with time varying probability, the limited dependent regression approach, the restricted vector auto-regression, and the signal approach indicators. The limited dependent regression and the indicator approaches are able to foresee some crises, but also they generate many false alarms. Various papers considered potential indicators of currency crisis. Some of the variables were significant in univariate tests but were not significant in multivariate tests. An EWS should take in consideration a large set of economic and sometimes political variables in constructing an EWS. Some variables received a plenty of support as a useful indicators of currency crises. These are foreign reserve, the real exchange rate, credit growth, credit to public sector, domestic inflation, exports growth, money growth, ratio of M2 to foreign reserves, real GDP growth, and the fiscal deficit. Banking sector problems may have predictive power of anticipating currency crises. Similarly, the real effective exchange rate is useful indicator of currency crisis because the real effective exchange rate is a reflection of the balance of payment condition.

The Markov-Switching model was investigated by Jeanne and Mason (2000), Fratzscher (2003), Cerra and Saxena (2002), Martinez-Peria (2002), and Abiad (2003). Abiad (2003) paper of EWS is based on a Markov-Switching model with time varying probability. This approach identify crisis period endogenously and allow the model to make use of information contained in the exchange rate dynamics. According to Abiad (2003), this model performs better than standard
EWS in signaling crises and reducing false alarm. Unfortunately, the computational requirement for this approach is not part of software programs, makes it difficult to verify his assertion, or testing the model for null or no switching, and the model may not converge when there are many explanatory variables. It is essential of taking in consideration the dynamic of exchange rate in building an EWS and to recognize that different indicators matter for different countries. One should not expect parameter consistency in all countries. Martinez-Peria (2002) looked at speculative attack on the European Monetary System for the period of 1979-1993 using five variables. Those variables were

domestic credit growth, imports-exports ratio, unemployment rate, fiscal deficit, and interest rate. He made an assumption of the existence of parameter consistency across countries. Abiad (2003) enlarged the above model and looked into 22 early warning indicators and rejected the idea of parameter consistency across countries. The parameter consistency assumption may be reasonable for industrialized countries, but not for developing countries due to different degrees of openness, external imbalance, and financial capital control.

The probit/logit approach was explored by Blanco and Garber (1986) and Sachs, Tornell, and Velasco (1996). The limited dependent regression approach (probit/logit) used the exclusion windows. The exclusion window omits the detection of any crisis that follow a previous crisis within a certain period of time. The exclusion window is intended to eliminate speculative pressure if it is just a continuation of previous one. Regrettably, this deletes the information regarding crisis duration. The width of the exclusion window is subjective, which has been chosen from one quarter to three years in different studies. The currency crisis indicators, of limited dependent regressions, data are zero-one variable and the explanatory variables are as a linear function. The prediction of the model between zero and one is taken-to-mean the probability of crisis. But, because the logit or probit functions are non-linear function, the contribution of a given variable is dependent on all other variables. Also, because the number of crises is limited, there are large numbers of zeros and few ones which leads to poor estimation result.

Krkoska (2001) used restricted vector auto-regression (VAR) to predict crises in transitional economy. The speculative pressure index is constructed and entered as endogenous variable. The other endogenous variables were the real exchange rate, industrial production, FDI, and current account. The exogenous variables were current account and foreign direct investment (CA-FDI) gap, growth in real domestic credit, inflation, exchange rate, and the industrial production in the EU. The researcher found that CA-FDI gap is the most important predictor of crisis. A crisis warning was transmitted when CA-FDI gap exceeded 5% of GDP.

The signal approach indicators started with Kaminsky, Lizondo, and Reinhart (KLR) (1998) and expanded by Berg and Pattillo (1999). KLR (1998) investigated the currency crises and built an early warning system (EWS). They suggested monitoring the behavior of some macroeconomic

variables to see if the chosen variables show abnormal behavior before a currency crisis compared with their behavior in their tranquil periods. KLR system is based on the idea that if an indicator exceeds a given value (threshold), that will be interpreted as a signal of currency crisis during the next two years. Other effective indicators for potential currency crisis were used by other researchers. These variables were foreign reserves, domestic credit, real exchange rate, credit to the public sector (debt), domestic inflation, banking sector problems, money growth, real GDP growth, and fiscal deficit. Also, from their study, they found no evidence of anticipating a currency crisis based on other indicators such as imports, difference between foreign and local interest rates on deposit, the ratio of interest rate of lending to deposit, and bank deposits. Berg and Pattillo (1999a) added the ratio of the current account balance to GDP, the ratio of M2 to reserves, as well as updating the data. The most widely used method for EWS is an indicator approach by creating an index of speculative pressure from changes in exchange rates, foreign reserves, and/or interest rates. Then weights are given for each of the above variables, specifying a threshold, and identifying crises when the speculative pressure index exceeds the threshold. The indicator approach is the adopted method in building the EWS for Jordan. The problem of this method is that the choice of crisis threshold is subjective. The crisis detection threshold varies from one study to the other (1.5, 1.645, 1.75, 2.5. and 3 standard deviations were used). A decrease in the threshold leads to an increase in false alarm. Unfortunately, different threshold would produce different crisis dates according to Abiad (2003) and Edison (2003). But fortunately/unfortunately for Jordan, the choice of crisis detection threshold in this study is determined by Jordan actual experience of 1988/1989 currency crisis.

DATA

In this study, data (of quarter one 1980 to quarter three 1988 and from quarter two 1990 to quarter two 2013) were obtained from the Ministry of Planning and International Cooperation. Some of the data were converted from yearly or monthly into quarterly data. Other data were taken from the Central Bank of Jordan. The explanatory variables are selected based on theoretical consideration and data availability. The explanatory variables were tested to identify the significant indicators, the thresholds of indicators, and to identify the occurrence of a currency crisis. Then some of these indicators were aggregated into composite index which would be used for predicting currency crises.

The variables were transformed into growth rate or ratio. The kind of transformation was guided primarily by theoretical consideration to achieve stationarity.

BUILDING AN EWS

Building an EWS requires dating a currency crisis, identifying the indicator threshold, building a composite index, and predicting a currency crisis. The indicators are mostly economic variables that have explanatory power or/and predictive power of the occurrence of a currency crisis. A signal approach indicator is rooted in the literature of predicting the turning point in the business cycle. The EWS monitors the behaviors of some indicators, mostly economic indicators, which tend to behave differently before a crisis. Identifying the economic variables for the EWS will provide excellent knowledge about the sources of a crisis.

INDICATORS

The choice of indicators was decided based on theoretical and statistical considerations, as well as the availability of data. The explanatory variables that were used for constructing index of speculative pressure (ISP) to predict a currency crisis were the real effective exchange rate, domestic credit for public sector, the ratio of M2 to international reserves, inflation, and current account without grants. More than 160 variables were tried unsuccessfully in building ISP for predicting currency crisis. These included adjustable rate mortgages, real exchange rate, exports, imports, real GDP, and per capita GDP. This study investigated the following variables that were used by Pasternak, Abiad (2003), Wu Jun (2007), and KLR (1999), as well as other variables:

Fiscal Variables: Budget deficit and government consumption expenditure give the investigator an idea about fiscal discipline. For Jordan, budget deficit was not a good indicator in univariate setting, but the threshold of government consumption was 1 standard deviation.

Monetary Variables: Real interest rate, difference in interest rate in Jordan and outside Jordan, foreign reserves, M2 growth, and M2 multiplier give the researcher an idea about monetary expansion and instability of financial intermediaries (explained later on).

Banking Supervision and Financial Fragility Variables: Banking crises, banking deposits growth, domestic credit growth, government debt, and the difference between interest rate on deposit and lending give an idea about the stability of banking system. An increase in the ratio of central bank credit to banks relative to total banking liabilities implies financial weakness. A higher ratio of bank deposits to M2 indicates an increase in the relative confidence of households and businesses have in the banking system. A high ratio of loans to deposits may imply banking system fragility and inadequate level of liquidity to respond to shocks. A high real interest rates increases nonperforming loans and indicates a lower level of financial sector soundness. For Jordan, the domestic credit and domestic credit growth were not good indicators in univariate setting. Government debt and the difference between interest rate on deposit and lending were not good indicators in univariate setting.

Current Account Variables: Exports growth, imports growth, current account balance, capital account balance, and real exchange rate show weakness in the local economy. For Jordan, the threshold of the growth rate of current account balance, without grants, was 1 standard deviation, even though was not a great indicator in univariate setting, but was an excellent indicator as part of the index.

Capital Account Variables: Foreign direct investment as percentage of GDP, foreign direct investment as a percentage of gross capital formation, and short-term debt show the vulnerability of the economy to the level of confidence of foreign investors in the local economy. For Jordan, the thresholds were -1.45 and -1 standard deviations for foreign direct investment and foreign direct investment as a percentage of gross capital formation respectively. But using the growth rate of the above two indicators showed that they were not good indicators in univariate setting. Short term debt was not applicable to Jordan since all government debt is long term debt.

GDP Growth and Per Capita GDP Variables: Declining GDP growth rate and gross capital formation reflect instability of the economy. Lower growth rate of per capita GDP implies weakness in

macroeconomics and therefore increase the risk of a currency crisis. The GDP growth rate threshold was -1 standard deviation and the GDP per capita growth rate threshold was -1 standard deviation. The real GDP and growth rate of real GDP per capita was not a good indicator in unvariate setting.

Real exchange rate: The real exchange rate RER) is a measure of trade competitiveness and the extent of under or over valuation. When domestic inflation rate is higher than that of foreign inflation rate, the real exchange rate of the local currency depreciates and the prices of non-tradable goods and services increase relative to those of tradable goods and services. Net exports of tradable goods and services will decrease due to imports substitution and a decline of international competitiveness. Jordan nominal exchange rate was pegged to the dollar since 1995 as a tool of anti-inflationary measure and building trust in the Jordanian currency. But the CPI in Jordan increased higher than that of the US because food and energy costs represent very significant portion of the Jordanian family income relative to that of the US. The combination of fixed nominal exchange rate and inflation in Jordan created a real appreciation of Jordanian currency. The Jordanian currency has 28% over valuation relative to its average value from 1990-1994. This over valuation of the dinar represents a major risk to the Jordanian economy. This problem should be addressed in prudent manner. For Jordan, RER and real effective exchange rate (REER) were not good indicators in univariate setting, but REER was an excellent indicator as part of an index.

Exports: If the decline of exports growth rate is the result of overvalued Jordanian currency, this lead to decline in competitiveness of Jordanian goods in relation to foreign goods. That would result in an increasing pressure on Jordan dinar for devaluation. For Jordan, exports growth rate was not a good indicator in univariate setting.

The Ratio of Domestic Credit to GDP: A high growth rate of the ratio of domestic credit to GDP means an increase in liquidity and may increase excess liquidity, capital outflow, and increase the economic vulnerability to currency crisis. For Jordan, the ratio of domestic credit to GDP was not a good indicator in univariate setting.

The Ratio of Short-Term Debt to Foreign Reserves: An attack on the currency would be triggered if there is high ratio of short term debt to reserves to the point where creditors realize that short term assets do not cover short term liabilities and reserves are not enough to satisfy all liquid claims. According to the ministry of Planning and International Cooperation, all Jordan government debts are long term debt.

Imports: If the growth rate of imports resulted in current account deterioration, this may lead to potential currency crisis. For Jordan, imports growth rate was not a good indicator in univariate setting.

Foreign Reserves: International reserves (IR) is an indicator of Jordan's ability to repay short-term debts, finance its imports, and prevent currency speculators of mounting an effective currency attack. For Jordan, IR threshold is -1 standard deviation and IR is good indicator, but the growth rate of IR is not a good indicator in univariate setting.

Real Interest Rate: A high real interest rate may indicate bank weaknesses and increase the danger of speculative attack. For Jordan, real interest rates threshold is .83 standard deviations in univariate setting, but was not a good indicator as part of the index.

Real Interest Rate Differential: A lower local interest rate in comparison of the global interest rate may lead to capital outflow and may turn into a currency crisis. For Jordan, the growth rate of interest rate differential was not a good indicator in univariate setting, but the interest rate differential with a threshold of one standard deviation was a good indicator in univariate setting.

The Lending to Deposits Interest Rate Ratio: The increase in the ratio of interest rate of lending to deposits may point out that banking sector is weakening and credit risk is rising. The weakness of the banking system may lead to weakness of the domestic currency. This higher ratio of lending to deposits interest rates may be due to low quality loans. For Jordan, the ratio of interest rate of lending to deposits was not a good indicator in univariate setting.

The Ratio of M2 to Foreign reserves: The high ratio of M2 to reserves leads to weakness of domestic currency and makes currency vulnerable to speculative attack. The high ratio makes central bank unable to provide foreign reserves in the event of individuals, corporations, and speculators decided to convert their M2 into foreign currencies. For Jordan, the threshold of the ratio of M2 to international reserves is 1.2 standard deviations, but 3 standard deviations for the growth rate of the ratio of M2 to international reserves.

Stock Prices: An end of stock bubbles and a decline in stock prices usually pave the way for currency crisis.

Excess Money Supply: Unjustified expansionary monetary policy may lead to a currency crisis.

Real Deposits: Domestic bankruptcy and capital outflow lower real deposits and increase the probability of a currency crisis. For Jordan, the threshold of the growth rate of real deposits is -1.25 standard deviations.

Industrial production: A decline of industrial production is an indication of recession and often precedes a currency crisis. For Jordan, the industrial production was not a good indicator in univariate setting.

Inflation: High inflation rate lead to high nominal interest rate, reduce net exports, and reduce international competitiveness. For Jordan, the threshold of inflation was -1 standardized deviation.

Indicators	**Threshold of Standardized Critical Value**
Growth in Current account (Excluding Grants) (%)	1
FDI & Portfolio Investments	-1.45
FDI & Portfolio Investments As % of total Investment (%)	-1
Nominal GDP Growth (%)	-1

GDP per Capita Growth (%)	-1
Gross Official Reserves (million JD)	.83
Interest Rate Differential (Jordanian Dinar –US$) (%)	1
M2 As % of Gross Official Reserves	1.2
M2 As % of Gross Official Reserves Growth (%)	3
Real Deposits Growth (%)	-1.25
Inflation Rate (CPI Based) (%)	-1
Index of Speculative Pressure (ISP)	1.25

The above explanatory variables are indicators of currency crisis. Some of these explanatory variables (indicators) are used into building composite index for the purpose of predicting currency crisis. The explanatory variables that are included into the composite index will be called significant indicators.

SIGNALING HORIZON

Signaling horizon to a period points to an index that has the capacity to predict a currency crisis and defined in this paper to cover the period of two years. A signal is considered a good signal if the crisis happened within two years. It is considered a noise or a false signal if a signal is not followed by a currency crisis within two years. A signaling window is the time horizon prior to a currency crisis when the ISP is predicting an approaching currency crisis. It should be noted that setting a suitable signaling window is arbitrary, but it is important for decision-makers. The signals would not be useful if the signals arrived too late for decision-makers to adjust their actions or policies to avoid a currency crisis. Longer signaling window is more useful for decision-makers to avert or alleviate the impact of a currency crisis. A signaling window of eight quarters is chosen in this paper, even though some use six quarters. This time horizon of eight quarters is consistent with the majority of the literature.

Signals and Thresholds: The signal approach is a bivariate method. The standardized ISP behaves differently before a crisis relative to tranquil period. An extreme value of the standardized ISP

provides a warning signal. This process gives a very good result if there is a clear distinction between crisis episodes and periods of tranquility, as the case for Jordan. The Jordan standardized index is said to transmit a signal whenever its value is above its mean by 1.25 standard deviations.

Persistence of the Signals: Another characteristic of excellent ISP is that the signal transmitted by the indicator is persistent preceding the crisis.

Building an Index and Signal-Generating Mechanisms: The index of speculative pressure (ISP) for Jordan follows Herrara and Garcia (1999) method. Kaminsky (1999) constructed a composite index by aggregating signals of different variables, while Herrara and Garcia (1999) aggregated the variables to construct the composite index, then used the index to generate the signal. Building a composite index to generate the signal may have an advantage of predicting a currency crisis since leading indicators are jointly drifting over some period of time.

The index of speculative pressure (ISP) is defined in the following manner:

ISP = % change in REER + % change in DCPUS + M2/IR +Inflation + % change in CAWOG Where

REER: Real Effective Exchange Rate

DCPUS: Domestic Credit to Public Sector

M2/IR: The Ratio of Money Supply M2 to International Reserves

CAWOG: Current Account without Grants

The ISP was standardized to have a mean of zero and variance equal to one. Standardization gives you the mean to avoid the issue of weight for each variable. The increase in the index implies a depreciation of the currency and a decline of foreign reserves. An increase in the index implies a pressure to sell the local currency.

One can identify a crisis by the behavior of the standardized ISP. If the standardized ISP above its mean by k standard deviations in any given periods, the periods were identified as crisis. For Jordan, a crisis is defined as a period in which standardized ISP at time t is greater than 1.25 standard deviations (the mean for standardized variable is zero). Based on Jordan historical record, one could avoid the false signal of the index if one defined a crisis as a period in which the standardized ISP at time t is greater than the mean plus 1.4 standard deviations. But using the 1.4 standard deviations will be less cautious than 1.25 standard deviations. To include an additional

variable in the index, one could use Granger causality test and decide to include it or not. Some variables have huge impact on currency crisis and are not easily quantified such as political vulnerability and banking supervision.

As can be seen in the appendix table (1), the Jordan standardized ISP produced an excellent signal preceding the crisis of 1988/1989. Also, the standardized index of speculative pressure (SISP) shows that no expected currency crisis for the next two years, 2016 and 2017.

Evaluation Criteria and analysis:

The evaluation is based on the following four statistics. These statistics are minimize the sum of Type I and type II errors, minimize the size of Type I error, minimize the noise-to-signal ratio, and maximize the probability that the crisis occurs given that the model produce the signal. Matrix of Possible Situations of Signals and Crisis

	Crisis within eight quarters	**No Crisis within eight quarters**	**Total**
Signal issued	A	B	A+B
No Signal issued	C	D	C+D
Total	A+C	B+D	A+B+C+D

In the above matrix, A is the number of quarters in which the index of speculative index (ISP) issued a good signal; B is the number of quarters in which the ISP issued a false signal (noise); C is the number of quarters in which the ISP failed to issue a signal; and D is the number of quarters in which the ISP did not issued a signal. An optimal distribution for an EWS happens when all signals are in sections A and D. However, errors turn out if a signal was sent out when no crisis occurs or a crisis happens and no signal was transmitted ahead of time. An increase in the threshold value produces fewer type B errors but increase type C errors.

Jordan ISP produced the following matrix of Possible Situations of Signals and Crisis

	Crisis within eight quarters	**No Crisis within eight quarters**	**Total**
Signal issued	4	2	6
No Signal issued	4	21	25

Total	8	23	31

Type I error:

Null hypothesis: crisis occurs

Alternative hypothesis: no crisis occurs

Size of Type I error = P(reject Ho given Ho is true) = probability of failing to anticipate the crisis = C/(A+C) = 4/8 = 50%

The perfect model would issue eight signals (with an eight quarter window).

Type II error:

Null hypothesis: crisis occurs

Alternative hypothesis: no crisis occurs

Size of Type II error = P(not rejecting Ho given Ho is false) = probability of sending false signal = B/(B+D) = 2/23 = 8.7%

Because type I and Type II errors are undesirable, the model that minimize the sum of both would be selected from a group of models. Or one chooses the model with the smallest Type I error because it is more costly not to anticipate the crisis.

The probability of a crisis is equal to (A+C)/(A+B+C+D) = 8/31 = 25.8%

Observations correctly predicted = (A+D)/(A+B+C+D) = 25/31 = 80.6%

Crises correctly predicted = A/(A+B) = 4/6 = 66.7%

Tranquil Periods correctly predicted = D/(B+D) = 21/23 = 91.3%

False alarm = B/(A+B) = 2/6 = 33.33%

The prediction errors of the composite index = (B+C)/(A+B+C+D) = 6/31 = 19.35%.

Evaluation Criteria:

The evaluation is based on the following four statistics. These statistics are minimize the sum of Type I and type II errors, minimize the size of Type I error, minimize the noise-to-signal ratio, and maximize the probability that the crisis occurs given that the model produce the signal. Matrix of Possible Situations of Signals and Crisis

	Crisis within four quarters	No Crisis within four quarters	Total
Signal issued	A	B	A+B
No Signal issued	C	D	C+D
Total	A+C	B+D	A+B+C+D

In the above matrix, A is the number of quarters in which the index of speculative index (ISP) issued a good signal; B is the number of quarters in which the ISP issued a false signal (noise); C is the number of quarters in which the ISP failed to issue a signal; and D is the number of quarters in which the ISP did not issued a signal. An optimal distribution for an EWS happens when all signals are in section A and D. However, errors turn out if a signal was sent out when no crisis occurs or a crisis happens and no signal was transmitted ahead of time. An increase in the threshold value produces fewer type B errors but increase type C errors.

Jordan ISP produced the following matrix of Possible Situations of Signals and Crisis

	Crisis within four quarters	No Crisis within four quarters	Total
Signal issued	3	3	6
No Signal issued	1	24	25
Total	4	27	31

Type I error:

Null hypothesis: crisis occurs

Alternative hypothesis: no crisis occurs

Size of Type I error = P(reject Ho given Ho is true) = probability of failing to anticipate the crisis = C/(A+C) =1/4 =25%

The perfect model would issue eight signals (with an eight quarter window).

Type II error:

Null hypothesis: crisis occurs

Alternative hypothesis: no crisis occurs

Size of Type II error = P(not rejecting Ho given Ho is false) = probability of sending false signal = B/(B+D) = 3/27 = 11.11%

Because type I and Type II errors are undesirable, the model that minimize the sum of both would be selected from a group of models. Or one chooses the model with the smallest Type I error because it is more costly not to anticipate the crisis.

The probability of a crisis is equal to (A+C)/(A+B+C+D) = 4/31 = 12.9%

Observations correctly predicted = (A+D)/(A+B+C+D) = 27/31 = 87%

Crises correctly predicted = A/(A+B) = 3/6 = 50%

Tranquil Periods correctly predicted = D/(B+D) = 24/27 = 88.89%

False alarm = B/(A+B) = 3/6 = 50%

The prediction errors of the composite index = (B+C)/(A+B+C+D) = 4/31 = 12.9%.

Jordan ISP produced the following matrix of Possible Situations of Signals and Crisis. The signaling period of four quarters and eight quarters

	Four quarters	**Eight quarters**
Size of Type I error	1/4 =25%	4/8 = 50%
Size of Type II error	3/27 = 11.11%	2/23 = 8.7%
The probability of a crisis	4/31 = 12.9%	8/31 = 25.8%
Observations correctly predicted	27/31 = 87%	25/31 = 80.6%
Crises correctly predicted	3/6 = 50%	4/6 = 66.7%
Tranquil Periods correctly predicted	24/27 = 88.89%	21/23 = 91.3%
False alarm	3/6 = 50%	2/6 = 33.33%
The prediction errors of the composite index	4/31= 12.9%	6/31 = 19.35%.

The prediction errors of the composite index is the combined possibilities that index issued a false signal and the index did not issue a signal but a currency crisis occurred within eight quarters. After normalizing the composite index, the probability of a currency crisis increases with the increase in the composite index.

A currency crisis occurs in a given period if the standardized ISP exceeds a threshold and this threshold is defined as a 1.25 standard deviations (SD) of the distribution of the standardized index.

Probability of currency crisis = .25 if standardized ISP ≥ 1.25 for one period

Probability of currency crisis = .5 if standardized ISP ≥ 1.25 for two consecutive periods

Probability of currency crisis = .75 if standardized ISP ≥ 1.25 for three consecutive periods

Probability of currency crisis = 1 if standardized ISP ≥ 1.25 for four consecutive periods Probability of currency crisis = 0 if standardized ISP ≤ 1.25

Conclusion

Implementation of an early warning system by emerging economies themselves, international financial institutions, and private creditors could thus help identify crisis vulnerabilities at an early stage and increase the odds of taking timely corrective action. The Jordan standardized ISP produced an excellent signal preceding the crisis of 1988/1989. In addition, the standardized index of speculative pressure shows that currency crisis is not to be expected for the next two years, 2016 and 2017. This research concentrated on the Jordanian market as a sample of emerging markets. Future research may apply the same empirical activities in different countries and compare the findings. This effort will, hopefully, lead to the discovery of a more generalizable model that will encompass most variables affecting the EWS.

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