

INDEX OF CURRENCY MARKET TURBULENCE AND ESTIMATION OF LEADING INDICATORS: THE CASE OF TURKEY

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Abstract

A currency crisis is a condition in which the exchange rate significantly depreciates for a short period of time. Currency crises have significant economic and social consequences. Therefore, many indices are created to determine the degree of pressure in economies and to forecast the financial crises. According to the Signal Approach, it is thought that a variable gives a warning signal that a crisis may occur if a variable goes beyond a certain threshold level. The main purpose of this study to investigate the validity of the Index of Currency Market Turbulence developed by Kaminsky and Reinhart for Turkey in the period January 1999- December 2019. The results show that the Index is working, and the formula is correct. The another aim is to determine the leading indicators with respect to the Index of Currency Market Turbulence in the prediction of crises by Vector Auto Regressive (VAR) Model. The leading indicators causing financial crises, are tried to be determined by using Index of Currency Market Turbulence. Vector Autoregressive analysis results show that Unemployment Ratio, Exports/Import ratio, and the Non-Residents' Equity Portfolio are exogenous, and other variables are not. Granger Causality test results show that the Unemployment Rate, Net International Reserves, US Dollar /TRL Currency Buying Rate and the Non- Residents' Equity Portfolio can be used as leading indicators. VAR analysis, variance decomposition and Granger Causality test results show that Unemployment Rate (UR), Net International Reserves (NIR), US Dollar/ TRL Buying Rate (USD/TRL), the Equity Portfolio of Non-Residents (NREP) can be used as leading indicators.

Keywords: Index of Currency Market Turbulence, Leading Indicators, VAR analysis, Granger Causality Test.

Jel Classification: G01, H60, C51

PARA PİYASASI DALGALANMA ENDEKSİ VE ÖNCÜ GÖSTERGELERİN TAHMİNİ: TÜRKİYE ÖRNEĞİ

Öz

Döviz kuru krizi, döviz kurunun kısa bir süre için önemli ölçüde değer kaybettiği bir durumdur. Döviz krizlerinin önemli ekonomik ve sosyal sonuçları bulunmaktadır. Bu nedenle, ekonomilerdeki baskı derecesini belirlemek ve finansal krizleri tahmin etmek için birçok endeks oluşturulmuştur. Sinyal Yaklaşımında, endeks değerinin belirli bir eşik seviyesini geçmesi durumunda bir krizin meydana gelebileceği konusunda bir uyarı sinyali verdiği düşünülmektedir. Bu çalışmanın temel amacı, Kaminsky ve Reinhart'ın geliştirdiği Döviz Piyasası Türbülans Endeksinin Ocak 1999- Aralık 2019 döneminde Türkiye için geçerliliğini araştırmaktır. Analiz sonuçları endeksin çalıştığını ve formülün doğru olduğunu göstermektedir. Diğer bir amaç da krizlerin tahmininde Döviz Piyasası Türbülans Endeksi'ne ilişkin öncü göstergelerin Vektör Oto Regresif (VAR) Modeli ile belirlenmesidir. Vektör Otoregresif analizi, İşsizlik Oranı, İhracat / İthalat oranı ve Yurtdışı Yerleşiklerin Hisse Senedi Portföyünün dışsal olduğunu ve diğer değişkenlerin olmadığını göstermektedir. Granger Nedensellik testi sonuçları ise, İşsizlik Oranı, Net Uluslararası Rezervler, ABD Doları / TRL Döviz Kuru ve Yurt Dışı Yerleşiklerin Hisse Senedi Portföyünün öncü göstergeler olarak kullanılabileceğini göstermektedir.

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VAR analizi, varyans ayrıştırması ve Granger Nedensellik testi sonuçları, İşsizlik Oranı (UR), Net Uluslararası Rezervler (NIR), ABD Doları / TL Satın Alma Oranı (USD / TRL), Yerleşik Olmayanların Öz Sermaye Portföyünün (NREP) öncü göstergeler olarak kullanılabilceğini göstermektedir.

Anahtar Kelimeler: Döviz Piyasası Türbülansı Endeksi, Öncü Göstergeler, VAR analizi, Granger Nedensellik Testi.

Jel Sınıflaması: G01, H60, C51

1. Introduction

The currency crisis is a case in which the foreign exchange rate has significantly depreciated over a short period of time. Eichengreen et al. (1994) define speculative attacks or crises as large movements in exchange rates, interest rates, and international reserve. Frankel and Rose (1996) explain that a devaluation of at least 25 percent in nominal value and a 10 percent decrease compared to the previous year leads to currency crush. The currency crisis literature contains the causes and consequences of a monetary crisis. The models in the literature are named as first, second or third generation. Krugman (1979) and Flood and Garber (1984) models are the main studies of the first-generation models. The main components of a first-generation model are purchasing power parity, budget constraints, timing of deficits, money demand function, government's ruling on the exchange rate and post-crisis monetary policy. Second generation models often imply more than one factor for speculative attacks occurring due to self-fulfilling expectations ((Obstfeld, (1994), Obstfeld (1997), Velasco, (1996)). The second-generation models is based on the logic that market players believe in the final failure of policymakers and thus defending the currency exchange rate can be expensive due to high interest rates. Consequently, the speculative attack in the currency can develop either as a result of fundamentally anticipated future deterioration or with a completely self-fulfilling prophecy. Third generation models emphasize the balance sheet decompositions associated with devaluations.

Banks and firms face credit risk in developing countries due to borrowing in Dollar or Euro and lending in local currency. Also, they are exposed to liquidity shocks since they finance long-term projects by short-term borrowing (Burnside, 2008). Mishkin (1996) argue that the position of banks whose liabilities are mostly in foreign currencies may further weaken when a devaluation occurs. The 1990s brought a new experience to the currency crisis. At the end of 1994, a serious currency crisis hits Mexico and other Latin American countries. In a few months, it especially splays to Argentina and Turkey. Two more years later, an unexpected and surprising series of financial crises hits South East Asia. The Asian crisis started in Thailand in July 1997 and has affected Malaysia, Indonesia and the Philippines. The next wave caused serious turmoil in Hong Kong in autumn 1997 and again in Indonesia. Singapore and Taiwan had been less affected. The cases in Asia have undermined investor confidence in emerging markets, especially Russia and Turkey, that are characterized by chronic fiscal imbalances. The troubles in Russia triggered the explosion of a money crisis in Brazil in early 1999 and some adverse contamination effects especially for other Latin American economies such as Argentina. Due to macroeconomic problems and difficulties experienced in the World, Turkey experienced a currency crisis in 2001.

As a result of the global crisis in 2008, the markets ease with the abundance of global liquidity. However, Turkey experienced a speculative attack in August of 2018.

The causes of currency crises are financial imbalances, current account deficit, overvaluation of exchange rate, country specific exchange rate system, structural problems in the banking and financial sectors and political instabilities. If money is being put into circulation by central bank at a rate exceeding the increase in money demand, the result will be a financial deficit, leading to the depletion of national reserves and the collapse of the currency. The current account deficit includes the cycle of over-spending and the overvaluation of money, which deteriorates a current account balance, reduces national reserves and finally leads to devaluation. Foreign exchange rates may be overvalued due to changes in the external environment, local supply shocks, policy-related reasons (for example, the limited credibility of the foreign exchange-based inflation-fighting program), the upward pressure on the exchange rate (Sasin, 2001). The currency crises between 1995 and 1999 are examples of exchange rate regimes in creating monetary crises. Asian crises have shown the importance of appropriate corporate governance, especially when large financial companies dominate the economy. Structural weaknesses and instability in the banking and financial sectors also cause crises. Market intermediaries think that the policymakers will protect the financial system from collapsing and that they can solve the problem with monetary expansion. This means that higher inflation is preferred over abandoning exchange rate stability. Thus, domestic investors rush to banks to withdraw balances, and to turn into a strong currency. This creates turmoils on the interest and exchange rate and often leads to currency crush and banking crisis. To prevent potential turmoils, governments choose to recover economically as soon as possible by performing a sharp devaluation. Turkey experienced such problems in 2001. The concept of political instability/vulnerability encompasses a wide variety of situations such as external or internal military coup and conflicts between governments and executive institutions in some countries (Dabrowski, 2002).

Many studies emphasize the role of the deterioration of economic indicators in monetary crises. Kamin and Rogers (1996) state that exchange rate-based stabilization policies are useful in accelerating the disinflation process, but this situation leads to overvalued exchange rates and large current account deficits. These factors make it difficult to stabilize exchange rates. As the anti-inflation program prolongs, its cost will increase and it brings more dependence on a tight monetary policy. Under these conditions, a tight monetary policy requires a change in the monetary response function to protect the exchange rate and this condition makes the economy more vulnerable to negative shocks. Frenkel (1997) also emphasizes that over the world with huge capital markets, there is not enough official reserves to stabilize at the wrong rates and there is no exchange rate policy that can protect the economy from errors on macroeconomic basis. However, currency crises can be generally predicted. Using the historical data in the panels of econometric models or the sections of countries, one can predict crisis in any degree of accuracy. However, the possible endogeneity problem of monetary policy in risk may also limit the predictability of crises.

Third generation models explain crisis through which balance sheet risks can lead to currency and the banking crisis.

The Speculative Pressure Index (Eichengreen, Rose and Wyplosz, 1996), Index of Currency Market Turbulences (Kaminsky & Reinhart, 1999), Banking Sector Fragility Index (Kibritçioğlu, 2003) and the Extreme Risk Index (Ural and Balaylar, 2007) have been formed according to the signal approach to measure the degree of pressure on financial markets and predict the crises. Eichengreen et al. (1994) suggest the Exchange Market Pressure Index (EMPI) formulated by weighted average of changes in exchange rates, official reserves and interest rates. The crisis is defined as the multiple of the standard deviation above the sample average, that is, the EMPI reaches an extreme value. The weight in the EMPI is due to different fluctuations of the components, and weights are different for each country. Sample mean and basic standard deviation can also be differentiated between countries. According to the signal approach, it is thought that a variable gives a warning signal that a crisis may occur if variable goes beyond a certain threshold level in the period before a crisis. Kaminsky et al. (1998) pioneered to this approach. Leading indicators are divided into variables. The next step in researching early warning indicators is to investigate the behavior of variables. Exports, overvalued real effective exchange rates, slowing gross domestic product growth, high ratio of large money (M2) to foreign exchange reserves and stock prices give reliable signals that a currency crisis may occur within the next twenty-four months when these variables exceed threshold values.

The 2008–2009 global financial crisis revives the interest of economists in designing and evaluating the performance of early warning systems, which is the model used to measure the probability of observing financial crisis periods in the short term. The currency attack in August 2018 in Turkey and high volatility in the international currency and stock market due to Corona Virus make signal approach agenda in analyzing recent days. In this regard, the main purpose constitutes the validity of Index of Currency Market Turbulence (ICMT) formed by Kaminsky and Reinhart (1999) for Turkey in the period of 1999- 2019 and determination of the leading indicators causing financial crises by using ICMT.

2. Literature Review

Researchers are always interested in predicting the time and form of currency crises, and there are many studies in the literature. The model of the balance of payments (Mundell, 1960) for testing the interdependence between the ability to fix a currency and the central bank's international reserve level is the first attempt to understand the causes of currency crisis. The studies in the literature are divided into two groups. The first group includes studies that propose parametric (regression-based) and non-parametric (early signal) models and evaluates the performance of the different signal approach. Signal approach studies are frequently applied in the literature. Girton and Roper (1977) create the Exchange Market Pressure Index using the monetary policy and balance of payments. Weymark (1995) constitutes a theoretical background for Girton and Roper's model. Eichengreen et al. (1994) form the Exchange Market Pressure Index using the signal approach. This study pioneered other research. Using the logit-probit model, Frankel and Rose (1996) examine 70 crises with 17 leading indicators on 105 developing countries in the period 1971-1992. Kaminsky, Lizondo and Reinhart (1998) (KLR) observe the indicators displaying an unusual behavior before the financial crisis. Jakubiak (2000) look for the components of the Exchange Market Pressure Index or 14 historical cases considered by the experts as a currency crisis.

Bussiere and Fratzscher (2006) have developed a multinomial logit regression-based early warning system that allows differentiation between calm periods, crisis periods and post-crisis periods. The multinomial logit model tends to predict the financial crisis in emerging markets better than the binomial logit model. Beckmann et al. (2006) apply parametric and nonparametric early warning systems using a sample of 20 countries between January 1970 and April 1995. Comelli (2014), also, compares the performance of parametric and nonparametric early warning systems for monetary crises in 28 emerging market economies and observes that parametric systems have better results.

Numerous studies prove the validity of the signal approaches in Turkey (Gerni et al. (2005), Bozkurt and Dursun (2006), Kaya and Yılmaz (2006), Altıntaş and Öz (2007), Katırcıoğlu and Feridun (2011), Çakmak, (2013), Öztürkler and Göksel (2013) Avcı and Altay, (2014), Gündoğan and Akal (2017), Akkaya and Kantar (2018). Arı and Cergiboz (2016) analyze Turkey's economy in the 1990- 2013 period using the logit model and observe the crisis. They conclude that 2 standard deviation is appropriate and prove the validity of the index by detecting the crisis. Yokuş and Ay (2020) make a comparative analysis of currency crisis and propose a definition of currency crisis specific to Turkey. Using the Exchange Market Pressure Index, the crisis occurs in the third quarter of 2018. Also, Almahmood, Munyif and Willett (2018) model provides the best explanation in detecting crisis in Turkish economy.

The second group studies for early warning systems consist of discussion of the importance of leading indicators or macroeconomic indicators to explain crisis. Corsetti et. al (1998) note that the Asian crisis is the result of weak macroeconomic foundations and a weak institutional environment. Yorgancılar and Soydal (2016), Uğurlu and Aksoy (2017) and Kaya and Köksal (2018), investigate the relationship between the Exchange Market Pressure Index and macro economic indicators in Turkey. Uğurlu and Aksoy (2017) observe a relationship between the current account deficit, interest rate, total liabilities and volatility index (VIX) index. Similarly, Yorgancılar and Soydal (2016) conclude that the loan/national income rate and the VIX index are significant on the Exchange Market Pressure Index. Also, Kaya and Köksal (2018) show one-way Granger causality from stock market to the Exchange Market Pressure Index using Vector Autoregression (VAR) analysis.

3. Methodology

The purpose of this study is to analyze the validity of the Index of Currency Market Turbulence (ICMT) formed by Kaminsky & Reinhart (1999) in Turkey and leading indicators in the estimation of crisis. Another aim is to determine the relationship between ICMT and the macroeconomic or financial variables.

The Index of Currency Market Turbulence developed by Kaminsky & Reinhart (1999) is one of the most used indices in studies, and it is based on the weighted average changes in exchange rates and reserves, and also calculated by the formula shown below. The variables in the formula are the US Dollar/Turkish Lira (TRL) exchange buying rate (E) and the international reserves (R).

$$ICMT = \Delta E/E - \left[\left(\frac{\sigma_E}{\sigma_R} \right) x(\Delta R/R) \right]$$

$\Delta E/E$: US Dollar / TRL Exchange Buying Rate (E) changes

$\Delta R/R$: International Reserves (R) changes

σ : Standard deviation

A crisis occurs if ICMT exceeds 2.5 standard deviation.

$$ICMT \geq \mu + 2.5 \sigma, \text{ crisis occurs.}$$

The changes in the Index of Currency Market Turbulence for January 1999- December 2019 period using quarterly data of US Dollar/TRL exchange buying rate and international reserves for Turkey are shown in Figure 1.

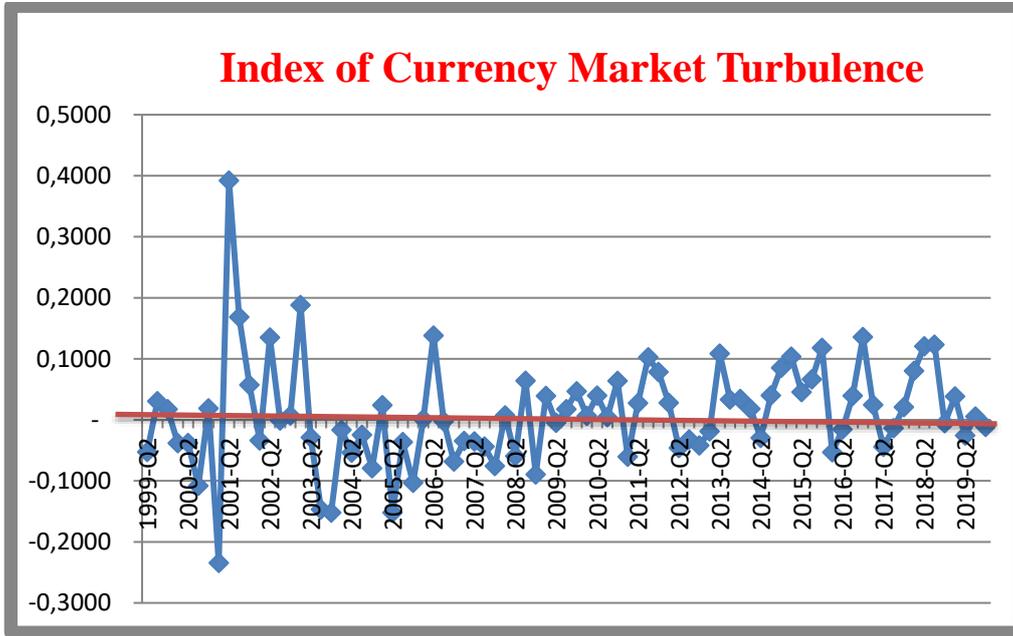


Figure 1. Changes in the Index of Currency Market Turbulence

Source: Author

Index of Currency Market Turbulence in Figure 1 reflects the crisis of the Turkish economy in 2001 and the Global crisis 2008 started in the USA and affected all economies. Turkish economy has started to be affected by the volatility after Bernanke- the President of the Federal Reserve of US America- announced in 2013 that the monetary expansion had come to an end and even the monetary contraction started. The Index also explains the July, 15 military coup in 2016, the currency crisis on August 10-12, 2018 and the subsequent economic contraction. Consequently, it is obvious that the Index of Currency Market Turbulence is valid in Turkey.

In order to determine the Index of Currency Market Turbulence as a leading indicator for the crises, a threshold value must be determined. The Index of Currency Market Turbulence is also named as the Exchange Market Pressure Index (EMPI) in the literature. The threshold values of these indices are presented in Table 1.

Table 1. Index of Currency Market Turbulence (ICMT)

Studies	ICMT (EMPI) Formula	Threshold Value
Eichengreen, Rose & Wyplosz (1996)	$EMPI = \frac{\Delta e}{\sigma_e e} - \frac{1}{\sigma_R} \left(\frac{\Delta R}{R} - \frac{\Delta R_{US}}{R_{US}} \right) + \frac{1}{\sigma_i} \Delta(i - i_{US})$	1,5σ ICMT
Milesi-Ferretti & Razin (2000)	$EMPI = \frac{e^s}{e} = \frac{1 - \Omega \left(\frac{eR}{M2} \right)}{1 - \eta\pi}$	%3, %5, %7
Edison (2003)	$EMPI = \% \Delta e - \frac{\sigma_e \% \Delta R}{\sigma_R}$	2,5σ ICMT
	$EMPI = \frac{\Delta \% RER}{\sigma_{RER}} + \frac{\Delta i}{\sigma_i} - \frac{\Delta \% R}{\sigma_R}$	
Bussiere & Fratzscher (2002)		2σ ICMT
Kumar, Moorth & Perraudin (2003)	$EMPI = \left[\frac{e_{t+\nabla} - e_t}{e_t} \right] \left[\frac{1 + i_t^f}{1 + i_t} \right] \%10, \%15$	
Licchetta (2009)	$EMPI = \frac{\Delta e}{e} - \frac{\sigma_e \Delta R}{\sigma_R R}$	2,5σ ICMT
Candelon, Dumitrescu & Hurlin (2014)	$EMPI = \frac{\Delta e}{e} - \frac{\sigma_e \Delta R}{\sigma_R R} + \frac{\sigma_e \Delta i}{\sigma_i}$	ICMT
Bucevska (2015)	$EMPI = \Delta e - \frac{\Delta R}{\sigma_R} + \frac{(i - i^f)}{\sigma_{(i-i^f)}}$	5σ ICMT
Ari & Cergibozan (2016)	$EMPI = \frac{\Delta \% RER}{\sigma_{RER}} - \frac{\Delta \% R}{\sigma_R}$	2σ ICMT
Kaminsky vd. (1998), Kaminsky & Reinhart (1999;1998), Nakatani (2018)	$EMPI = \frac{\Delta e}{e} - \frac{\sigma_e \Delta R}{\sigma_R R}$	3σ ICMT
Almahmood, Munyif & Willett (2018)	$EMPI = \frac{\Delta \% e}{\sigma_e} - \frac{\Delta \% R}{\sigma_R} + \frac{\Delta \% i}{\sigma_i}$	2 & 3σ ICMT

R: currency reserves, e: nominal exchange rate, i: interest rate, i^* : world interest rate, Ω : money base multiplier

M2: broad money supply, η : semi-elasticity of interest to money demand, π : loan growth.

∇ : Interest period e^s : dummy exchange rate

Source: Yokuş & Ay, 2020: 11

The Index of Currency Market Turbulence in the absolute value and the recommended threshold value are shown in Figure 2.

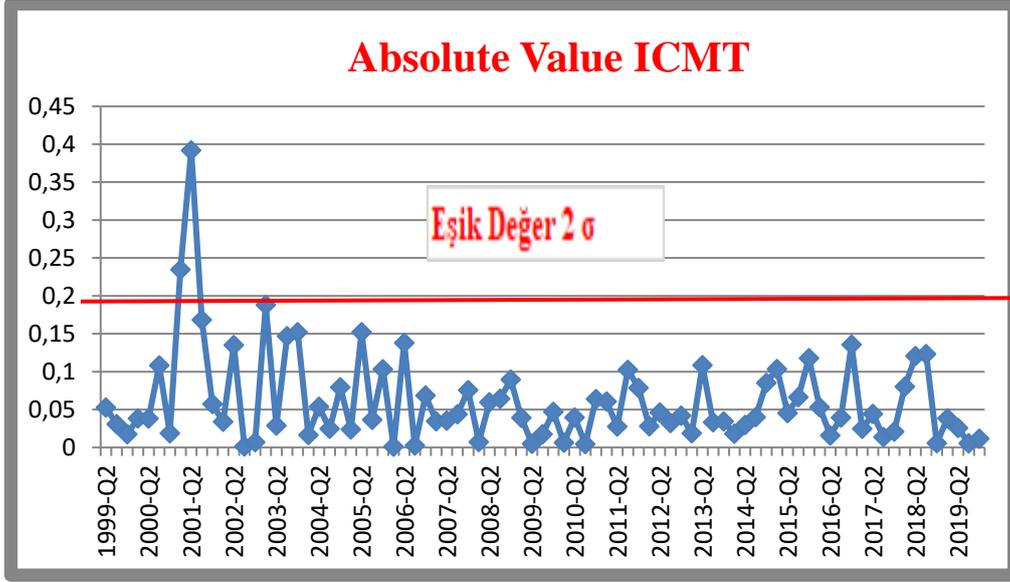


Figure 2. Threshold value of ICMT

Source: Author

The threshold value of the Index of Currency Market Turbulence is determined to be 2 standard deviation by Arı and Cergibozan (2016) for the period 1990 - 2013 and 3 standard deviation by Yokuş and Ay (2020) for the period 2006 - 2018. Figure 2 proves that 2 standard deviation is appropriate for threshold value in January 1999 - December 2019 period for Turkey. 2 standard deviation is consistent with the results of Arı and Cergibozan (2016).

Another aim of this study is to determine the leading indicators with respect to the Index of Currency Market Turbulence in the prediction of crises. To determine the leading indicators and to predict the crisis, 27 variables (18 macroeconomic and 9 financial) are analyzed for the period of January 2002 - December 2019 (Table 2). A study using VAR analysis was conducted by Akçorağoğlu in 2000.

Table 2. Variables and Abbreviations of Variables

Abbr.	Variable	Abbr.	Variable
GOLD	Gold Price	IPI	Industrial Production Index
BIST	Borsa İstanbul 100 return Index	MICUR	Manufacturing Ind. Capacity Utilization Rate
BSCV	Banking Sector Credit Volume	NEO	Net and Error Omission
CCI	Consumer Confidence Index	NIR	Net International Reserves
CD	Current Deficit	NREP	Non-Residents' Equity Portfolio
CPI	Consumer Prices Index	PI	Portfolio Investment
DBS	Domestic Debt Stock	RER	Real Exchange Rate
EXPIMP	Export Import Ratio	TRLDEPO	TRL Deposit Interest Rate
EXP	Export Volume	UR	Unemployment Rate
FDI	Foreign Direct Investment	USD 10Y	USD 10 Year Bond Rate
FTB	Foreign Trade Balance	USD Index	USD Dolar Index
INF	Inflation Rate	USD/TRL	US Dolar/TRL Buying Rate
IMP	Import Volume	VIX	Volatility Index

Source: Author

Borsa İstanbul 100 Return Index, TUIK Consumer Confidence Index data are from the institutions' own websites, other data is obtained from Central Bank of Republic of Turkey.

4. Analysis and Findings

The research covers the period of January 2002 - December 2019 and there are 1,216 monthly observations in total. The monthly proportional changes of the selected data are analyzed in the study. The research model is Vector Auto Regressive (VAR) Model, which includes the lagged values of all exogenous and endogenous variables.

Except for the US Dollar / TRL Buying Rate, Net International reserves, Borsa Istanbul 100 Return Index and the Nonresidents' Equity Portfolio, there is a low correlation between the Index of Currency Market Turbulence and the selected variables. US Dollar/TRL Buying Rate is 0.7781, Net International reserves - 0.7906, Borsa Istanbul 100 Return Index - 0.4125 and Nonresidents' Equity Portfolio - 0.4963. The high correlation with these variables are in the expected direction.

In finance and economics studies, time series should be stationary, that is, the unit root should not be as it causes spur regression and misleading results. In this study, Augmented Dickey-Fuller (ADF) test by Dickey and Fuller (1981) is applied.

Table 3. ADF Unit Root Test Results

	t-statistics	Prob.	1. Diff.	Prob.		t-statistics	Prob.	1. diff.	Prob.
ICMT	-6,887508	0.0000			NEO	-14,70633	0.0000		
GOLD	-11,99758	0.0000			NIR	-12,59848	0.0000		
BIST	-15,83596	0.0000			PI	-14,60133	0.0000		
BSCV	-5,715547	0.0000			RER	-11,65429	0.0000		
CD	-12,82229	0.0000			IPI	-3,127387	0.0261	-11,199	0.0000
FTB	-13,68958	0.0000			CPI	-8,507315	0.0000		
FDI	-11,47821	0.0000			TLDEPO	-7,074101	0.0000		
INF	-14,81681	0.0000			CCI	-13,64718	0.0000		
DBS	-12,29126	0.0000			USD/TRL	-10,7572	0.0000		
EXPIMP	-4,105716	0.0012			USD Index	-14,92872	0.0000		
EXP	-14,80278	0.0000			USD 10Y	-14,68521	0.0000		
MICUR	-18,32409	0.0000			VIX	-17,38478	0.0000		
UR	-3,084696	0.0293	-11,743	0.0000	NREP	-13,28689	0.0000		
IMP	-2,709257	0.0742	-10,262	0.0000					

Source: Author

Table 3 shows that the series sustains any unit root at 1% significance level, that is, they are stationary except for the Unemployment Rate (UR), Import Volume (IMP) and Industrial Production Index (IPI). Non-stationary variables become stationary at the first difference and necessary transformations are made for correction.

For the VAR analysis, the optimal lag length must first be determined. VAR Optimal Lag Length Criteria are presented in Figure 3. The longest length, that is LR (sequential modified LR test statistic) is determined as 2 (two) lag lengths and included in the model.

Figure 3: Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	3554.829	NA	2.54e-48	-32.97036	-32.54569*	-32.79876*
1	4434.242	1528.699	6.48e-49*	-34.37609*	-22.48508	-29.57106
2	5082.659	963.5348*	1.82e-48	-33.62298	-10.26562	-24.18451

* the delay order selected by criterion by Eviews

VAR Granger Causality/Block Exogeneity Wald Test is applied to determine the relationship between the Index of Currency Market Turbulence (ICMT) and the variables. The results of the model are significant at the level of 5%. The results show that the variables of Unemployment Rate (UR), Export Import Ratio (EXPIMP) and Nonresidents' Equity Portfolio (NREP) are exogenous, and other variables are not. In other words, the lagged values of other independent variables except above show that they are not significant on ICMT (Table 4).

Table 4. VAR Test Results

Dependent Variable: ICMT			
Excluded	Chi-sq	Df.	Prob.
GOLD	0.808554	2	0.6675
BIST	1.261541	2	0.5322
BSCV	1.103707	2	0.5759
CD	0.969551	2	0.6158
UR	9.530848	2	0.0085
DIMP	5.224388	2	0.0734
DIPI	0.788910	2	0.6740
FTB	5.548965	2	0.0624
FDI	1.608479	2	0.4474
INF	0.607904	2	0.7379
DBS	1.719683	2	0.4232
EXP	5.367597	2	0.0683
EXPIMP	9.731225	2	0.0077
MICUR	4.227506	2	0.1208
NEO	0.985846	2	0.6108
NIR	3.196359	2	0.2023
PI	0.130695	2	0.9367
RER	2.134783	2	0.3439
CPI	0.168350	2	0.9193
TRLDEPO	1.092173	2	0.5792
CCI	3.627911	2	0.1630
USD10Y	1.058822	2	0.5890
USD/TRL	3.672827	2	0.1594
USDINDEX	1.498827	2	0.4726
VIX	4.357367	2	0.1132
NREP	6.738445	2	0.0344
All	73.76318	52	0.0252

Source: Author

Assumptions of the VAR model, such as regression models, need to be tested. Necessary assumption tests are performed, and autocorrelation, heteroscedasticity and multicollinearity don't take place in the model.

Impulse-Response analysis has been applied to monitor the response of the dependent variable in VAR by giving 1 unit of shock to each of the variables and the results obtained from the Impulse-Response analysis. ICMT increases firstly as a reaction to shock by unemployment rate.

The effect of shock decreases and turns negative in the 4th month and becomes ineffective in the 6th month. ICMT also response in the increase to the ratio of exports to imports and the impact of its shock decreases and becomes ineffective in the 4th month. In addition, ICMT reacts the Non-Residents' Equity Portfolio in a decrease, and its shock turns into a positive response in the 4th month and becomes ineffective in the 5th month.

Results obtained from the impulse-response functions are also shown in the table below (Table 5).

Table 5. Impulse-Response Function Results

Period	ICMT	DUR	EXPIMP	NREP
1	0.058907 (0.00285)	0.000000 (0.00000)	0.000000 (0.00000)	0.000000 (0.00000)
2	0.020269 (0.00429)	-0.002566 (0.00421)	-0.001658 (0.00415)	-0.018350 (0.00407)
3	-0.004003 (0.00421)	0.008154 (0.00412)	0.003446 (0.00393)	0.000470 (0.00433)
4	0.000308 (0.00302)	0.007236 (0.00375)	-0.000318 (0.00199)	0.000750 (0.00221)
5	0.000827 (0.00105)	0.002568 (0.00209)	-0.001117 (0.00145)	-0.000665 (0.00119)
6	-4.17E-05 (0.00082)	-0.000145 (0.00119)	0.000677 (0.00075)	-0.000344 (0.00065)
7	-1.00E-05 (0.00036)	-0.000613 (0.00073)	0.000126 (0.00034)	-9.73E-05 (0.00034)
8	1.45E-05 (0.00015)	-0.000328 (0.00037)	-0.000182 (0.00021)	0.000132 (0.00016)
9	2.44E-05 (8.4E-05)	-0.000132 (0.00020)	4.14E-05 (9.3E-05)	3.66E-05 (7.8E-05)
10	-5.79E-06 (3.8E-05)	3.31E-06 (0.00012)	1.34E-05 (4.0E-05)	-1.84E-05 (4.9E-05)

Source: Author

Variance Decomposition results for 10 periods of variables are presented in Table 6. The huge part (88.89%) of the error variance in ICMT is explained by itself. Nonresidents' Equity Portfolio (NREP) explains 7.71%, Unemployment Rate (UR) 3.02% and Export Import Ratio (EXPIMP) 0.38%. According to the variance decomposition results, Nonresidents' Equity Portfolio (NREP) is the most significant on the ICMT.

Table 6. Variance Decomposition results

Period	S.E.	ICMT	UR	EXPIMP	NREP
1	0.058907	100.0000	0.000000	0.000000	0.000000
2	0.065015	91.81294	0.155808	0.065017	7.966240
3	0.065738	90.17369	1.690949	0.338421	7.796944
4	0.066141	89.08109	2.867148	0.336621	7.715142
5	0.066209	88.91448	3.011688	0.364382	7.709454
6	0.066213	88.90235	3.011755	0.374796	7.711096
7	0.066216	88.89423	3.020039	0.375125	7.710607
8	0.066218	88.89102	3.022384	0.375866	7.710728
9	0.066218	88.89061	3.022768	0.375904	7.710721
10	0.066218	88.89060	3.022768	0.375908	7.710728

Source: Author

Granger causality test gives information about the direction of relationships and is applied to determine the short-term relationship between the variables. The causality test results between the ICMT and the variables are presented in Table 7.

Table 7. Pairwise Granger Test Results

Variables	F-statistic	Prob	Variables	F-statistic	Prob
GOLD-ICMT	2.50128	0,0844	NEO - ICMT	0.51489	0,5983
ICMT - GOLD	0.23249	0,7928	ICMT - NEO	0.23979	0,7870
BIST - ICMT	3.26995	0,0400	NIR - ICMT	3.02488	0,0507
ICMT - BIST	0.60347	0,5479	ICMT - NIR	1.29089	0,2772
BSCV - ICMT	2.20507	0,1128	PI - ICMT	0.02800	0,9724
ICMT - BSCV	5.17495	0,0064	ICMT - PI	0.54663	0,5797
CD-ICMT	0.03195	0,9686	RER - ICMT	1.55987	0,2126
ICMT - CD	0.25349	0,7763	ICMT - RER	0.02170	0,9785
FTB - ICMT	0.94550	0,3901	IPI - ICMT	0.34280	0,7102
ICMT - FTB	0.27325	0,7612	ICMT - IPI	0.28860	0,7496
FDI - ICMT	0.93948	0,3925	CPI - ICMT	0.14251	0,8673
ICMT - FDI	3.01944	0,0510	ICMT - CPI	9.32109	0,0001
INF - ICMT	0.75603	0,4708	TRLDEPO - ICMT	1.10094	0,3345
ICMT - INF	0.53777	0,5849	ICMT - TRLDEPO	20.9401	5.E-09
DBS - ICMT	0.06854	0,9338	CCI - ICMT	2.65893	0,0724
ICMT - DBS	0.56450	0,5695	ICMT - CCI	2.72536	0,0679
EXP - ICMT	0.36606	0,6939	USD 10Y - ICMT	0.31301	0,7316
ICMT - EXP	1.50832	0,2237	ICMT - USD 10Y	2.49929	0,0846
EXPIMP - ICMT	0.63941	0,5286	USD INDEX - ICMT	1.81419	0,1655

Variables	F-statistic	Prob	Variables	F-statistic	Prob
ICMT - EXPIMP	1.32449	0,2682	ICMT - USD INDEX	0.11891	0,8879
MICUR - ICMT	1.77961	0,1713	USD/TRL- ICMT	3.21313	0,0422
ICMT - MICUR	1.46073	0,2344	ICMT – USD/TRL	0.38856	0,6785
UR - ICMT	3.12884	0,0458	VIX - ICMT	2.47563	0,0866
ICMT - UR	0.06631	0,9359	ICMT - VIX	0.03095	0,9695
IMP - ICMT	0.99048	0,3731	NREP- ICMT	11.6415	2.E-05
ICMT - IMP	4.02049	0,0193	ICMT - NREP	1.04098	0,3549

Table 7 proves that there is a one-way Granger causality from Unemployment Rate (UR), Net International Reserves (NIR), US Dollar/TRL Buying Rate (USD/TRL), Nonresident's Equity Portfolio (NREP) and Borsa İstanbul 100 Return Index towards ICMT. In other words, these changes are significant on the ICMT. In addition, a one-way causality from the ICMT to Banking Sector Credit Volume (BSCV), Direct Investments (FDI), Import volume (IMP), Turkish Lira Deposit Interest Rate (TRLDEPO) and Consumer Price Index (CCI) occurs.

5. Conclusion

Many money crises/financial crises and their types occur in the world. In the financial literature, these crises are divided into three groups. Currency crises have become a very popular topic of academic and political discussions with thousands of publications in recent years. Because the money crises in the developing and transition economies have important consequences. Production and employment losses, real income, investment and capital inflows decrease, dilapidated country credibility, etc. are some of the economic and social consequences of crises.

Currency crises and their economic and social consequences are in the area of great importance. Thus, forecasting of leading indicators to predict crisis is crucial. The causes of foreign exchange crises are financial imbalances, current account deficit, overvaluation of exchange rate, the role of specific exchange rate regimes, structural weaknesses in the banking and financial sectors and political instabilities. Different econometric models are used to determine the variables causing currency crises. The most used one among these models is the signal approach. Girton and Roper (1977) create the Exchange Market Pressure Index, and Weymark (1995) formed the theoretical infrastructure of this model. Eichengreen et al. (1994) create the Currency Pressure Index using the signal approach. Kaminsky et al. (1998) led the signal approach to come to the fore with its studies.

The aim of this study is to measure the the validity of Index of Currency Market Turbulence (ICMT) formed by Kaminsky & Reinhart (1999) for Turkey in January 1999 - December 2019 period and to determine the leading indicators in the prediction of the crisis. The study proves that Kaminsky & Reinhart (1999)'s Index of Currency Market Turbulence (ICMT) is valid in Turkey. Also, ICMT threshold value should be 2 standard deviation. These results are consistent with Arı and Cergiboz (2016). VAR analysis is applied to determine the relationship between ICMT and variables. Unemployment rate (UR), Export Import Ratio (EXPIMP) and Nonresidents' Equity Portfolio (NREP) are exogenous, and other variables are not. Variance decomposition test states that Nonresidents' Equity Portfolio (NREP) is the most significant on the ICMT.

Moreover, there is a one-way Granger causality from Unemployment Rate (UR), Net International Reserves (NIR), US Dollar/TRL Buying Rate (USD/TRL), Non-Resident's Equity Portfolio (NREP) and Borsa İstanbul 100 Return Index towards ICMT. VAR analysis, variance decomposition and Granger Causality test results show that Unemployment Rate (UR), Net International Reserves (NIR), US Dollar/TRL Buying Rate (USD/TRL), the Equity Portfolio of Non-Residents (NREP) can be used as leading indicators.

This result is both theoretically and statistically significant. Because Net International Reserves (NIR) and US Dollar/TRL Buying Rate (USD/TRL) are the main variables of the index. The results that these two variables are significant show that the Index is working and the formula is correct.

Increases in Unemployment Rate (UR) will cause the employees to remain without income and increase in the budget deficits due to the decrease in consumption and taxes to be collected. Increases in the budget deficit lead to ascend in the prices of public services and inflation. Turkey is intense in countries where dollarization will cause the exchange rate to rise. Nonresident's Equity Portfolio (NREP) is also associated with net international reserves. Huge increases in NREP will cause capital inflows to the country, falling exchange rates and increasing reserves. Otherwise, the situation where the capital outflows increase will lead to the depletion of the reserves.

In this case, policy makers will either have to raise interest rates or take necessary measures, including capital controls. Such a situation may damage the consumer and investor confidence. Both situations can lead to deterioration of macroeconomic indicators and ultimately financial turmoil and crises.

The econometric model of this study is Vector Autoregressive Analysis. Other studies can contribute to the literature by using Artificial Neural Networks, Algorithm models, Cointegration Tests and other models. In addition, risk premium and contagion effect of emerging countries due to Corona Virus may be topic for future researches.

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