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Early Warning Indicators for Systemic Banking Crises: Household Debt and Property Prices

(Penunjuk Amaran Awal untuk Krisis Perbankan Bersistem: Hutang Isi Rumah dan Harga Perumahan)

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ABSTRACT

The 2008 financial crisis was the result of escalating house prices and a hasty increase in household debt. In a sample of 41 advanced and emerging countries, this paper employs a logit estimation model to examine the role of household debt and house price as indicators of systemic banking for the period of 1980 until 2018. The results confirm that a high growth in household debt and house price increase enhances the probability for crises to erupt. While this is a consistent evidence for advanced economies, an observation of emerging economies suggests that only a change in household debt and not a change in house prices may cause banking crises to erupt. Policymakers can thus design predictive EWS models based on the surge in household debt and house prices prior to the crises which would lessen, if not alleviate, the effect of upcoming economic shocks by monitoring the macroeconomic changes.

Keywords: Early Warning Signal; household debt; house prices; banking crises; logit

ABSTRAK

Hutang isi rumah dan harga hartanah telah meningkat dengan ketara dipercayai penyebab kepada krisis kewangan 2008. Makalah ini mengkaji peranan hutang isi rumah dan harga rumah sebagai penunjuk krisis perbankan sistemik melalui 41 sampel negara maju dan negara sedang pesat membangun untuk tempoh 1980 hingga 2018 menggunakan model logit. Penemuan kajian ini mengesahkan bahawa krisis cenderung untuk berlaku apabila terdapat pertumbuhan hutang isi rumah yang tinggi serta kenaikan harga rumah. Manakala penemuan ini konsisten dengan negara maju, pemerhatian mendapati bahawa hanya perubahan hutang isi rumah dan bukan perubahan harga rumah penyebab krisis di negara pesat membangun. Oleh itu, penggubal dasar boleh merekabentuk model ramalan EWS berdasarkan peningkatan mendadak dalam hutang isi rumah dan harga rumah sebelum krisis yang dapat membantu mengurangkan, jika tidak meringankan, kesan kejutan ekonomi yang akan datang melalui pemantauan perubahan makroekonomi.

Kata Kunci: Sistem Amaran Awal; hutang isi rumah; harga rumah; krisis bank; logit

INTRODUCTION

According to Alter and Mahoney (2020), a country's economic stability is significantly influenced by house price and household debt. Kim (2020) asserts that the surge in house price along with a hasty increase in household debt were the causes of the 2008 economic recession. Mian et al. (2017) further contend that household debt vitally enhances the probability for banking crises to erupt. Household debt may link to the symptoms of financial crises in numerous ways. For instance, evidence from the 2008 economic recession among European countries, the United Kingdom and United States suggests a deeper subsequent recession following the strong increase in credit expansion during the boom (see Alter et al. 2018; Bunn & Rostom 2015; Justiniano et al. 2016; Mian et al. 2015). Jorda et al. (2013) provide further proof over this consistency in which similar features were observed on more than 200 recessions with slower recovery among 14 advanced countries using regional data of 1870-2008. Others have found that the pre-financial crisis period eased credit constraints, but that house price surged in tandem with aggregate mortgage debt (see Dagher & Kazimov

2015; Haughwout et al. 2019; Justiniano et al. 2016). Whereas house price was evidently a symptom of the 2008 Great Recession, the increase in available credit with connected to a declined standard of lending and financial liberalisation were further causes of the crisis, and these strongly relate to corruption (Jha 2019).

Hence, the likelihood for banking crises to erupt in many countries is explained by the phenomenon of escalating debt within households and the effect of house prices. The gravity of the issue has caused the International Monetary Fund (IMF) to produce two reports pertaining to household debt and house prices for the year 2017 and 2018 respectively to caution any relevant parties against disregarding the matter. The IMF (2017) report claims that economic growth was affected by the reversed effect of household debt which significantly increased the odds of a financial crisis. Hence, rising household debt must be taken into serious consideration when it comes to economic stability and to avoid a similar crisis. According to IMF (2019), the high magnitude of economic crises observed for the past few decades was led by a price boom in the housing sector. Widespread in some markets, house price gains have been, in others, rather brisk. In many cities and countries within emerging and advanced market economies, house price growth runs parallel to the crisis's run-up (IMF 2018). Additionally, there have been strong evidences proving that escalating household debt which leads to crises in many advanced economies is in tandem with high house prices (Goodhart & Hofmann 2008; Kim, Son & Yie 2017).

Motivated by this scenario, we focus our study in analysing the indicators for Early Warning Signal or EWS (i.e. household debt and house price) as important indicators for systemic banking crises. Limited studies have emphasised the impact of household debt on banking crises. Büyükkarabacak and Valev (2010) and recent studies highlight its relationship with economic recession (see Alter et al. 2018; Garcia 2020; Kim 2020). Few, on the other hand, have focused on house price together with rising household debt as an important indicator for banking crises. This issue demands an urgent study to recommend appropriate policies before another round of crisis. Thus, there is a need examine the issue of systematic banking crises via EWS that is comprised of house price and household debt.

This study contributes to the literature in three-fold. It extends existing EWS banking crises model with household debt and house prices as simultaneous indicators. The study also uses split sample advanced and emerging economies in its analysis. A plethora of studies have discussed the matter of household debt and crises in the context of advanced countries. Hence, this study fills the gap by contributing to the literatures with evidence inclusive for the economies of emerging and advanced countries. This study further contributes through its provision of comparable proofs between the said economies. Barrell and Karim (2013) had earlier raised a similar issue which brought attention to the inherent heterogenous country which may lead to bias in the result. Though most advanced countries show a median increase in household debt between 50 to 65 percentage of GDP (IMF 2017), there is also a tremendous increase in household debt in emerging markets post- financial crisis with a sharp increase by more than 50 percentage of GDP in Thailand, Malaysia and Korea according to BIS statistics. Hence, the study analyses the panel data by pooling all countries together and to also split sample in order to obtain consistent and robust results. As preview, empirical findings prove that banking crises are likelier to erupt due to changes in household debt and house price. Additionally, the results in relation to advanced economies are in accordance to prior studies. The likelihood for crises in the banking sector to happen can be prompted by a growth in household debt, albeit statistically insignificant with the change in house price for emerging economies.

The paper adheres to the following structure: section 2 details the review of literature, section 3 presents the used dataset and testable equations; section 4 discussed the employed method of estimation together with the empirical findings; and section 5 concludes the study and offers several recommendations in relation to related policies.

LITERATURE REVIEW

Previous studies have largely focused on early warning models with various approaches. A seminal study in this area was Kaminsky and Reinhart's (1998) effort in using the signal approach to examine 76 currency crises and 26 banking calamities among five industrial countries and 15 developing ones from 1970 to 1995. The evolution of their work was extended to banking, financial, and economic crises. Later, using the multivariate logit model in their sample of developing as well as developed nations, Demirgüç-Kunt and Detragiache (1998) attempted to identify EWS associated with banking crises for the period 1980 to1994. The model was extended when Bussiere and Fratzscher (2006) employed the multinomial logit regression-based EWS to capture three differing financial observations (i.e. periods of tranquillity, crisis and post-crisis) among 20 emerging economies from 1993 until 2001, and proved that their multinomial logit model was consistent and robust.

THE ROLE OF HOUSEHOLD DEBT AND HOUSE PRICE IN BANKING CRISES MODEL

Analysts have shown that the US economic crisis in the 1980s was led by mortgage lending (Holt 2009). The collapse in the mortgage markets, which were part and

parcel of household debt composition, had been cited as the main reason for the recession in 2008 and 2009 in the country (Dynan 2012; Stockhammer 2013). The identical reason had caused the financial crisis in 2008 and its aftermath to be widely referred to as the "Great Recession." Analysing a dataset covering 48 US states from the years 1929 to 1939, Gärtner (2013) confirmed that household debts overhangs (i.e. lower income ration to debt) slowed down the economic recovery. Considerable empirical evidences had been collected and the latest findings matched the facts presented above (see Alter et al. 2018; Lombardi et al. 2017; Mian et al. 2017; Samad et al. 2020).

A similar correlation was discovered by Schularick and Taylor (2012) using a long historical panel of 14 developed countries from 1870 to 2008 as increases in household leverage was a powerful predictor of financial crises in post-war crises. Jorda et al. (2013) proved that debt accumulation caused costlier financial crises than normal recessions since the calamities were not only on output but also on investments, lending, interest rate and inflation. Mian et al. (2015) employed panel vector-autoregressions (VARs) to produce cross-sectional evidence for 30 economies and elucidated that household debt was at a peak during the economic boom from 1960 to 2012 and saw remarkable reduction during the burst of the financial crisis in 2008. In a further study, it was confirmed that a unique business cycle was observable for household debt and its increase to GDP led to lower succeeding growth in GDP, higher unemployment and forecasted to cause negative global growth in developing and developed economies (Mian et al. 2017). Bańbuła and Pietrzak (2017) asserted that the credit boom prior to the recent financial crisis was mainly contributed by rising household debt based on their data in Sweden. Their study was focused on the EWS for non-crises countries. In another recent study, Alessi and Detken (2018) argue that household debt is useful as indicator to assess economic stability among European Union members. Relatively, limited studies have focused on emerging countries, particularly on household debt as indicator for crises.

Mendoza and Terrones (2008) argued that even though credit booms tend to associate with a majority of market crises in emerging economies, not all booms would result in financial crises. They postulated that booms in credit were experienced in 22 emerging economies and 27 industrial countries. However, their study and another research by Gorton and Ordonez (2020) similarly concluded that as not all credit boom would end with crises. Providing a contrasting view, Büyükkarabacak and Valev (2010) showed that economic instability was generated by a hasty increase in household debt that can hurry a banking crisis in their analysis of 37 emerging and developed markets for the period 1990-2007. Although a considerable number of researches showed a link between debt growth and crises as discussed, Barrell and Karim (2013) opine that the pool of study combining developing and developed markets could be biased due to country heterogeneity. Here, they showed that the role of credit growth was stronger in a country with financial constrains (i.e. emerging economy). Tamadonejad et al. (2016) analysed the indicators of EWS for banking crises in East Asian countries and proved that the chances for a depreciation in exchange rate and short-term debt caused a higher chance for crises with political instability and ineffective regulatory framework. In their study of an emerging country, Garber et al. (2019) proved that the tremendous increase in household debt preceded Brazil's economic recession. Nevertheless, in a more recent study of 23 emerging economies, Tunay et al. (2020) found opposite evidence showing that crises in the banking sector were headed by the current account deficit and systemic risk as consequence from credit default which explained the twin crisis hypothesis.

In their study, Jorda et al. (2015) extended an earlier dataset to 17 advanced economies and made clear that the sharp increase in housing lending during the pre-2008 crisis caused a deeper economic downturn and sluggish recovery. They extended their research by scrutinising the function of credit lending and interest rate and proved that both played significant roles in house price bubble. Cecchetti and Kharroubi (2015) displayed that resource allocation was distorted by credit booms especially in the construction sector, leading to a slowdown in productivity growth. Lowe (2017) found that household debt placed upward pressure on house prices accompanied with slowed household earnings, and created a high demand from Australia's population growth and foreign investors. He concluded that the recent increase in household debt relative to earnings made the economy less resilient to future shocks. Another study made evident of household debt's inherent pivotal role in mortgage defaults during the crisis using a panel of credit file data between 1999 and 2013 (see Albanesi et al. 2017). Meanwhile, Barrell et al. (2020) proved that economic growth was dampened by the acceleration of house price as driven by credit booms on a sample of 18 OECD countries during 1978 to 2016. These studies highlight the strong role of household debt accompanied with house price on financial crises.

House price can also be attributed as a trigger to banking crises aside from household debt (Kaminski & Reinhart 1999; Reinhart & Rogoff 2010; 2013). While some studies claim that credit can potentially be an early warning indicator, on the contrary, house price can therefore be a late warning indicator. Cardarelli et al. (2009) found that the strong downward trend in house prices resulted in an economic downturn and that financial crashes affected the banking system. However, Babecký et al. (2013) studied among OECD and EU countries between 1970 and 2010 and found evidence which suggest the decrease in house price

during the crisis, hence considered as an ultra-early warning indicator. Haughwout et al. (2019) explained that before the Great Recession, there was a strong rise in housing price during the 2003-2006 period. The rise even exceeded 10 percent during the boom years. As such, empirical evidences have provided a clear picture of how house price triggers the probability for banking crisis to erupt. Indeed, vast studies have found that credit, particularly mortgage credit, would increase tremendously a few years prior to the crises as a consequence of asset prices inflation (IMF 2017; Kim et al. 2017). On a sample of OECD countries, this precisely proved that lagged house prices were prone to banking crises based (see Barrell et al. 2010). Alter and Mahoney (2020) reconfirmed that house price and household debt may precipitate economic recession based on their analysis of US counties. In a panel sample analysis of 53 countries, Cerutti et al. (2017) postulate that household debt and house price are linked together and in turn cause twin crises. Thus, the phenomenon confirmed the hypothesis in which house price and household debt growth could be significantly measured as early warning signals for systemic banking crises.

Pertaining to emerging countries, Yip et al. (2017) put forward that the rapid house price appreciation triggers housing market bubble in Malaysia which connects with debt within the household at a high level. Daud and Marzuki (2019) confirm that asset accumulation is a key contributor to Malaysia's high level of household debt. Similarly, Ohnishi et al. (2019) found house price volatility may precipitate banking instability. In other country, Coskun et al. (2020) present a different finding in which the Turkish housing market experienced a boom because of price overvaluation but did not lead to a housing bubble. In Korea, Jang et al. (2018) claim that the previous financial crisis was associated with real estate market. However, this scenario will not likely cause a future crisis. Nonetheless, they suggest vigilance against other economic activities. These evidences highlight the role of household debt and house price as early indicators for systemic crises in banking. Hence, the present study adds to the current literature by providing further empirical evidence in its comparison of advanced and emerging economies.

METHODOLOGY

Demirgüç-Kunt and Detragiache's (1998) seminal work introduced us to systemic banking crises through a multivariate logit analysis. As such, the current study adheres to their method. However, data in the present study is updated to include more years of the crises than that in Demirgüç-Kunt and Detragiache's (2005)

TABLE 1. List of Countries and Systemic Banking Crises

Country	Systemic Banking Crisis (Laeven & Valencia, 2013)	Country	Systemic Banking Crisis (Laeven & Valencia, 2013)
Australia			
Austria	2008	Japan	1997
Belgium	2008	Korea	1997
Brazil	1990, 1994	Luxembourg	2008
Canada		Malaysia	1997
Chile	1976, 1981	Mexico	1981, 1994
China, P.R.	1998	Netherlands	2008
Colombia	1982, 1998	New Zealand	
Czech Republic	1996	Norway	1991
Denmark	2008	Poland	1992
Finland	1991	Portugal	2008
France	2008	Russia	1998, 2008
Germany	2008	Singapore	
Greece	2008	South Africa	
Hong Kong		Spain	1977, 2008
Hungary	1991, 2008	Sweden	1991, 2008
India	1993	Switzerland	2008
Indonesia	1997	Thailand	1983, 1997
Ireland	2008	Turkey	1982, 2000
Israel	1977	United Kingdom	2007
Italy	2008	United States	1988, 2007

investigation. As this study aims to prove that the 2008 financial crisis was triggered by household debt and house prices, the study therefore focuses on the crises which occurred around that time. For an updated version of the dependent variable, Laeven and Valencia's (2013) recorded dataset of banking crisis was adopted, in which the binary dummy is defined as in either two conditions: (i) significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidations); and (ii) significant banking policy intervention measures in response to significant losses in the banking system. Hence, the dummy value is 1 for each observation, otherwise taking a zero value. The dummy variable is denoted by CRISIS. Table 1 identifies the years when the study's sample countries experienced systemic banking crises. To note, the data for household debt and house price was retrieved from Bank International Settlement (BIS). However, the data for household debt across the countries is limited to only 43 countries. Hence, the study analyses 41 countries from advanced and emerging countries within a timeframe of 1980-2018 in the empirical analysis, excluding Argentina and Saudi Arabia due to data unavailability.

BASELINE SPECIFICATIONS

As for the fundamental explanatory variables, data was sourced from Demirgüç-Kunt and Detragiache (1998). The study confirmed for crises eruption likelihood upon observing the macroeconomic variables (i.e. low GDP growth, large fiscal deficits, high interest rates and inflation). Apparently, crises also occurred when the monetary side (i.e. broad money to foreign exchange reserves, the credit to private sector/GDP and lagged credit growth) were positive and significant. Meanwhile, institutional factors (i.e. insurance deposits and high GDP per capita) also lower the likelihood of crises.

This study follows a modified version of Davis and Karim's (2008) method in a previous study. It considers macroeconomic factors along with the monetary side in the equation and does not include GDP per capita due to the huge difference between advanced and emerging economies following a prior study by Barrell et al. (2010). The testable equation with an extension of household debt (HD), growth of household debt ($HDTG_{t-1}$) and real house prices ($HPIR_{t-1}$) is as follows:

$$\begin{aligned} SBC = {} & \beta_0 + \beta_1 GDP + \beta_2 OPEN + \beta_3 DEP + \beta_4 RIR \\ & + \beta_5 INF + \beta_6 FISCAL + \beta_7 FC + \beta_8 HD + \beta_9 HDTG_{t-1} \\ & + \beta_{10} HPIR_{t-1} + \varepsilon_t \end{aligned} \quad (1)$$

Thus, the testable equation for crisis in this study is where $SBC_{i,t}$ at i cross country and t time index depends on β_0 as constant measure and β_j, (j = 1…10) as coefficients with respect to real GDP growth *GDPG*, trade balance *OPEN*, nominal depreciation *DEP*, real interest rate *RIR*, inflation *INF*, fiscal surplus *FISCAL*, and financial contagion *FC*, household debt *HD*, growth of household debt $HDTG_{t-1}$ and real house price $HPIR_{t-1}$. This study is interested in investigating the role of household debt as part of the leading indicators for economic crises. The empirical literature highlights credit growth as a powerful predictor of economic misery (see Büyükkarabacak & Valev, 2010; Jorda et al., 2013; Mian et al., 2017; Schularick & Taylor, 2012). This has been confirmed in a recent study by Geršl and Jašová (2018) which showed that the ratio between credit to GDP was a powerful signal to crises. However, as this study wishes to challenge a prominent idea in that household debt serves as the best signaling variable, it thus focuses exclusively on indicators that are available from the same sources, i.e. BIS data on credit to the household.

On other spectrum, the study views the growth of total credits to household prior the economic downturn as part of the leading indicators for crises. The hypothesis centres around the sudden decline in household debt prior to the US's 2008 economic downturn (see Mian et al. 2017). Many studies have claimed household debt as one of the leading indicators for EWS or EWM (see Babecký et al. 2013; Joy et al. 2017). Though there have been no conclusive findings to show that household debt is associated to crises, Babecký et al. (2012)we examine stylized facts of banking, debt, and currency crises. Banking turmoil was most frequent in developed economies. Using panel vector autoregression, we confirm that currency and debt crises are typically preceded by banking crises, but not vice versa. Banking crises are also the most costly in terms of the overall output loss, and output takes about six years to recover. Second, we try to identify early warning indicators of crises specific to developed economies, accounting for model uncertainty by means of Bayesian model averaging. Our results suggest that onsets of banking and currency crises tend to be preceded by booms in economic activity. In particular, we find that growth of domestic private credit, increasing FDI inflows, rising money market rates as well as increasing world GDP and inflation were common leading indicators of banking crises. Currency crisis onsets were typically preceded by rising money market rates, but also by worsening government balances and falling central bank reserves. Early warning indicators of debt crisis are difficult to uncover due to the low occurrence of such episodes in our dataset. Finally, employing a signaling approach we show that using a composite early warning index increases the usefulness of the model when compared to using the best single indicator (domestic private credit contend that the rising household debt during economic expansions anticipates banking crises as a consequence which leads to currency crises. The definition of data used is described in Table 2.

TABLE 2. Data and Sources

Dependent Variable				
Dummy	SBC	Crisis =1, otherwise zero		Laeven and Valencia (2013)
Independent Variables				
Household debt	HD	Credit to the household percentage of GDP of the country.	+	BIS
Growth of household debt	HDTG	The total of real credit to the household in US Dollar of the country.	+	BIS
Real house price	HPIR	Real house price index of the country.	+	BIS
Real GDP growth		The growth of Gross Domestic Product at constant price.	-	The World Bank
Trade balance	OPEN	A country's trading terms.	-	The World Bank
Nominal depreciation	DEP	A country's rate of nominal exchange.	+	International Monetary Fund (IMF)
Interest rate	RIR	A country's treasure/short term rate of interest.	+	IMF/The World Bank/OED
Inflation	INF	A country's consumer index prices.	+	The World Bank
Fiscal surplus/GDP	FISCAL	Fiscal balance of the country.	-	The World Bank
Financial contagion	FC	The bank liquid reserves of total asset of the country.	+	The World Bank/Financial Structure Database

Note: Measurement for all variables is based on yearly frequency.

METHOD OF ESTIMATION

This study estimates the panel model using a distribution of cumulative logistic. It links the likelihood in which the dummy takes a value of one to the logit of the cross section explanatory variables' vector. The probability of crises for each economy *i* at given date *t* is given by:

$$Prob\left(SBC_{i,t}=1\right)=F\left(\beta X_{it}\right)=\frac{e^{\beta X_{it}}}{1+\ e^{\beta X_{it}}}, \quad (2)$$

where $SBC_{i,t}$ is the banking crisis dummy SBC=1 for country i at time t otherwise SBC=0, β is the vector of coefficients, X_{it} is the vector of explanatory variables with respect to real GDP growth $GDPG$, change in terms of trade $OPEN$, nominal depreciation DEP, real interest rate RIR, inflation INF, fiscal surplus $FISCAL$, and financial contagion FC, household debt HD, growth of household debt $HDTG_{t-1}$ and house prices $HPIR_{t-1}$. $F(\beta X_{it})$ is the cumulative logistic distribution. The estimation of eq. (2) requires linearising the relationship $F(\beta X_{it})$ as in eq. (3):

$$log_e\ L = \sum_{i=1}^{n}\sum_{t-1}^{T}[\begin{pmatrix} SBC_{i,t} log_e\ F\left(\beta' X_{it}\right)) \\ +(1-SBC_{i,t} \end{pmatrix} log_e \begin{pmatrix} 1- \\ F\left(\beta' X_{it}\right) \end{pmatrix}] \quad (3)$$

The maximum likelihood (ML) approach is adopted to estimate the coefficients of eq. (3) and to forecast the probability of total financial emergencies. The presenting signs β directly interprets the X_{it} may increase or lower the crisis probability, but the values are meant for direct marginal effect or relationship.

The next step is to access the quality of model specification. Three different types of model evaluators were employed, i.e. Akaike's information criterion (AIC) in-sample classification accuracy of crisis episodes, and Receiver Operating Characteristic (ROC) statistics. The AIC and non-parametric approach of crisis episodes model evaluators are widely used to compare the best Early Warning Signal model following Kaminsky and Reinhart (1999). AIC involves a comparison of the regressors' model with the intercept model in order to determine their joint significance, in which a smaller AIC indicates a better model. The prediction of crisis episodes reports the percentage of crises, non-crises, and observations that are correctly classified. Attaining a 70 percent accurate overall classification of banking crises signals the fairly well performance of the model. Another model accessor, ROC, follows Minoiu et al. (2013) and Comelli (2014). It is used to measure and augment the benchmark model's forecast ability. ROC reports the link between true and false positives for a series of likelihoods. A higher ROC statistic depicts a better model. These model evaluators are very useful for policymaking purposes in choosing the most consistent and best parsimonious model.

RESULTS AND DISCUSSION

The variables included are; systemic banking crises (SBC), growth of gross domestic product (GDPG), trade openness (OPEN), depreciation (DEP), real interest rate (RIR), inflation (INF), fiscal balance (FISCAL), broad money (FC), household debt (HD), household debt growth (HDTG) and house price index

(HPIR). Table 3 demonstrates a descriptive summary of systemic banking crises model. The systemic financial emergencies are indicated by dummy variable 0 or 1. The average for GDP growth is 2.83 and the lowest value is -9.13 percent (Greece) and highest growth is 25.9 percent (Ireland). The trade balance has mean 0.78 percent with the lowest value equals to -14.7 percent (Portugal) and highest is 25.92 percent (Singapore). The depreciation stands for foreign exchange exposure has average value of 98.5 percent, ranging from 48 percent (Russian Federation) to 165.88 percent (Korea).

TABLE 3. Summary of Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
SBC	0.028	0.165	0	1
GDPG	2.829	2.921	-9.132	25.117
OPEN	0.78	5.627	-14.652	25.92
DEP	98.483	14.348	47.953	165.877
RIR	6.978	7.941	-.554	67
INF	4.92	10.091	-5.992	143.693
FISCAL	-2.66	4.116	-34.315	16.267
FC	81.429	53.501	14.212	431.354
HD	50.28	29.69	0.1	139.4
HDTG	11.308	37.845	-83.934	1094.005
HPIR	91.208	27.726	24.372	187.96

The mean of real interest rate was 7 percent, with the lowest value -0.55 percent (Finland) and the highest value 67 percent (Turkey). Conjunctly, the average value of inflation was 4.9 percent, with lowest value -6 percent (Malaysia) and the highest value 143.7 percent (Turkey). It is not surprising that the inflation and interest rates were very high in Turkey since the country experienced financial crisis in 2000 and 2001. The fiscal balance had a mean equal of -2.7 percent with variation ranging from –34.32 percent (Portugal) to 16.27 percent (Singapore). Financial contagion, on the other hand, had an average value of 81.4 percent with the lowest value equal to 14.2 percent (Colombia) and 431.4 percent (Luxembourg). The average value of household debt ratio was 50.3 percent with variation ranging from 0.1 percent (Turkey) to 139.4 percent (Denmark). The growth of household debt averaged at 11.3 percent, with the lowest growth -84 percent (Turkey) and the highest growth 1,094 percent (Turkey). Finally, the mean for house price index was 91.2 percent with the variation ranging from 24.37 percent (Brazil) to 188 percent (Japan).

Table 4 lists the main variables' (i.e. household debt and house price) average values for the investigated economies. Generally, the statistics suggest much variation in household within the countries and in the advanced and emerging economies, but small variation in GDP growth. The level of household debt on average is higher in advanced countries but few other emerging

TABLE 4. List of Countries and Average Values of Selected Variables

Country	GDPG	HD	HPIR	Country	GDPG	HD	HPIR
Switzerland	1.908	113.455	99.131	Finland	2.209	43.99	76.43
Denmark	1.757	107.444	90.08	Singapore	5.81	42.825	87.28
Netherlands	2.162	92.145	81.613	Belgium	1.88	42.454	70.475
Ireland	4.823	80.512	109.214	France	1.807	39.036	71.403
Australia	3.148	75.036	68.069	Greece	0.981	38.328	84.928
United States	2.634	71.349	100.642	Israel	4.008	38.126	101.662
New Zealand	2.808	70.269	88.086	South Africa	1.664	37.8	99.91
Norway	2.475	67.723	70.178	Chile	3.865	33.459	114.116
United Kingdom	2.16	66.887	71.3	China	8.932	31.492	98.205
Canada	2.384	66.162	75.677	Italy	1.234	26.723	79.441
Korea	5.114	65.438	103.292	Poland	4.202	21.425	90.979
Malaysia	4.925	62.092	123.236	Czech Rep.	2.735	20.146	103.375
Japan	1.955	62.085	130.541	Brazil	2.287	18.887	83.818
Sweden	2.171	60.038	70.547	Hungary	2.141	18.11	104.221
Germany	1.801	58.367	118.428	Colombia	3.259	17.443	97.928
Luxembourg	2.683	55.741	110.138	Indonesia	5.293	13.283	111.168
Hong Kong	3.763	54.759	94.414	Mexico	2.474	12.036	104.351
Thailand	4.211	50.032	108.275	India	6.826	9.867	142.041
Portugal	1.966	49.113	93.665	Russia	3.467	9.133	70.052
Spain	2.316	48.792	64.262	Turkey	4.723	7.245	109.649
Austria	1.914	48.692	104.085				

economies inherent a similar feature such as Korea, Malaysia, Hong Kong and Thailand. Meanwhile, the lower level of household debt is mostly inherent in emerging countries except for Finland, Belgium, France, Greece and Italy in which these countries experienced banking crises in 2008. Additionally, house price is dispersed across the countries regardless of advanced or emerging economies.

Table 5 reports the pairwise correlation analysis with p-values for both groups of countries for the studies variables. The upper matrix of the table shows pairwise correlations for emerging economies, whereas the lower matrix presents the pairwise correlations for advanced economies. First, the correlations between household debt and banking crises are positive and significant in advanced countries and comparable to emerging countries. In a finding that is similar to that of many previous studies, there is a pronounced correlation between crises and household debt in advanced economies. However, there is a significant and negative change and growth in household debt. Second, the correlation of house prices and crises is stronger in advanced economies and statistically insignificant. Third, the significance of the interest variables in emerging countries are absent except for trade balance which signify statistically significant and negative correlations. As the findings appear puzzling, a logit estimator may therefore be appropriate to respond to this puzzle.

The growth of GDP, trade balance, real interest rate, fiscal balance and change in household debt growth are negatively correlated with banking crises. Meanwhile, depreciation, inflation, broad money and household debt are positively correlated with crises. Among the variables in the table of correlation matrix, GDPG, OPEN, DEP, INF, FISCAL, FC, HD and HPIR are consistent with theoretical assumption. Table 6 shows the explanatory variables' VIF values and the variables' VIF do not exceed the cut-off of 10 and stand at 1.55, indicating no serious collinearity problems.

Report of the estimates and predictive power of the logit model for determinants of systemic banking crises is presented in Table 6 with four different models. The report also demonstrates three reported quality model specifications; AIC, predictive classification of crises periods, and ROC statistics. The models were adjusted with different combinations of household debt, change of household debt, house price and change in house price in order to obtain the final and best model specification.

TABLE 5. Pairwise Correlation Matrix for Systematic Banking Crises Model

	SBC	GDPG	OPEN	DEP	RIR	INF	FISCAL	FC	HD	HDTG	HPIR
SBC	1	-0.08	-0.088	-0.024	0.055	0.064	-0.036	-0.081	-0.071	-0.03	0.019
		(0.1)	(0.07)	(0.62)	(0.26)	(0.19)	(0.51)	(0.11)	(0.14)	(0.54)	(0.73)
GDPG	-0.136	1	0.116	0.122	-0.137	-0.024	0.273	0.052	-0.018	0.224	0.083
	(0.00)		(0.02)	(0.01)	(0.01)	(0.63)	(0.00)	(0.32)	(0.71)	(0.00)	(0.13)
OPEN	-0.061	0.077	1	0.188	-0.213	-0.11	0.634	0.432	0.403	-0.027	-0.272
	(0.12)	(0.05)		(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.59)	(0.00)
DEP	0.099	-0.102	-0.059	1	-0.226	-0.377	0.274	0.411	0.605	-0.034	0.065
	(0.01)	(0.01)	(0.13)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.5)	(0.24)
RIR	-0.014	0.009	-0.253	0.052	1	0.556	-0.294	-0.205	-0.325	0.136	-0.209
	0(.71)	(0.81)	(0.00)	(0.16)		(0.00)	(0.00)	(0.00)	(0.00)	0.006	(0.00)
INF	-0.025	0.092	-0.165	-0.013	0.552	1	-0.164	-0.303	-0.447	0.218	-0.114
	(0.5)	(0.01)	(0.00)	(0.73)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.04)
FISCAL	-0.046	0.151	0.305	-0.08	-0.218	-0.1	1	0.204	0.295	0.061	-0.271
	(0.26)	(0.00)	(0.00)	(0.05)	(0.00)	(0.01)		(0.00)	(0.00)	(0.27)	(0.00)
FC	0.083	-0.091	0.195	-0.088	-0.334	-0.276	0.067	1	0.617	-0.087	0.036
	(0.03)	(0.02)	(0.00)	(0.02)	(0.00)	(0.00)	(0.12)		(0.00)	(0.09)	(0.55)
HD	0.08	-0.134	0.181	-0.006	-0.552	-0.467	0.213	0.272	1	-0.149	0.17
	(0.03)	(0.00)	(0.00)	(0.87)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HDTG	-0.092	0.232	-0.09	-0.006	0.109	0.12	0.055	-0.075	-0.143	1	-0.141
	(0.01)	(0.00)	(0.02)	(0.88)	(0.00)	(0.00)	(0.18)	(0.06)	(0.00)		(0.01)
HPIR	0.083	-0.065	0.057	0.002	-0.537	-0.414	0.14	0.485	0.495	-0.02	1
	(0.03)	(0.09)	(0.16)	(0.96)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.61)	

Probability value respected to significance level in parentheses *** p<0.01, ** p<0.05, * p<0.10

Table 7 shows the estimated coefficients of macroeconomic and monetary variables with a focus on the variables of interest (i.e. household debt and change in household debt growth) in predicting the systemic banking crises in Model 1. Household debt and change in household debt growth showed a positive and significantly predictive power in triggering a crisis, thus a consistency with Büyükkarabacak and Valev's (2010) finding in which household debt triggers crisis and causes negative growth to the economy. The lagged household credit growth shows a positive coefficient and significantly preceded the crisis. Mian et al. (2017) reported that household debt to GDP prior to the global economic emergency in the US recorded the highest point since the past decades. Additionally, Cecchetti et al. (2011) and Alter and Mohaney (2018) forecasted that the current household debt could cause a negative growth in the future using a cross country analysis.

GDP growth and trade balance were statistically negative, indicating that higher GDP growth and improvement of trade openness will likely decrease the likelihood of a crisis. It suggests that countries

TABLE 6. Variance Inflation Factor

	RIR	OPEN	INF	HPIR	FISCAL	FC	HD	GDPG	HDTG	DEP	Mean VIF
VIF	2.32	1.767	1.74	1.62	1.558	1.47	1.45	1.276	1.251	1.061	1.551
1/VIF	0.431	0.566	0.575	0.617	0.642	0.68	0.69	0.784	0.799	0.943	

TABLE 7. Early Warning Signal Model for Systemic Banking Crises

Variables	(1) SBC	(2) SBC	(3) SBC	(4) SBC
GDPG	-0.354***	-0.353***	-0.352***	-0.244***
	(0.09)	(0.096)	(0.094)	(0.082)
OPEN	-0.098	-0.04	-0.053	-0.111*
	(0.06)	(0.071)	(0.072)	(0.065)
DEP	0.076***	0.062***	0.062***	0.059***
	(0.022)	(0.023)	(0.023)	(0.019)
RIR	-0.138	-0.002	-0.024	-0.049
	(0.113)	(0.118)	(0.115)	(0.099)
INF	0.185*	0.163	0.124	0.186***
	(0.1)	(0.099)	(0.096)	(0.069)
FISCAL	0.035	0.049	0.074	0.141
	(0.087)	(0.097)	(0.096)	(0.089)
FC	0.007*	0.005	0.005	0.007*
	(0.004)	(0.004)	(0.004)	(0.004)
HD	0.022**	0.012		
	(0.01)	(0.011)		
LAG HDTG	0.048***	0.054***	0.053***	
	(0.013)	(0.014)	(0.014)	
LAG HPIR	0.049***	0.051***	0.043***	
		(0.014)	(0.014)	(0.012)
Constant	-13.444***	-16.646***	-15.741***	-14.065***
	(2.609)	(3.098)	(2.885)	(2.379)
N	664	588	588	645
Pseudo R2	0.2648	0.3296	0.323	0.2489
Log-Likelihood	49.38***	57.54***	56.39***	46.09***
BIC	202.0712	187.1562	181.9312	197.2848
AIC	157.073	139.012	138.164	157.062

Probability value respected to significance level in parentheses *** p<0.01, ** p<0.05, * p<0.10

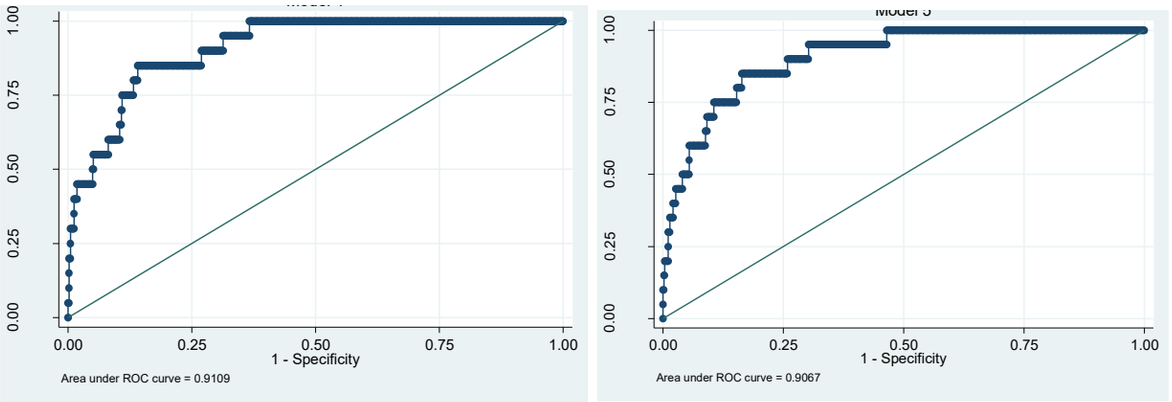

FIGURE 1. ROC Statistics

TABLE 8. ROC Statistics and Predictive Ability (cut-off probability = 0.05)

	(1)	(2)	(3)	(4)
Variables	SBC	SBC	SBC	SBC
ROC Statistics	0.7914	0.8046	0.8794	0.9109
P-values comparing ROC statistic Model 2 and 3			0.5113	
Total correct	13	15	15	14
% crises correct	61.9	75	75	66.67
% no crises correct	85.09	86.8	87.5	86.38
% total correct	84.36	86.39	87.07	85.74

with a serious current account deficit amidst economic slowdown are prone to crisis. Meanwhile, depreciation, inflation and broad money were significant and positive predictive power for crises. A higher exposure to foreign exchange and further inflated consumer price index will intensify the likelihood for a country to face a financial crisis. Conversely, the chance for capital flight and subsequent probability of a twin crisis or pure banking is intensified with the positive probability on broad money which indicates an increase in un-backed money (Davis & Karim 2008). Although the signs of coefficients are consistent with the underlying theory, private credit and credit growth show an insignificant probability for crises which is opposite to the credit crunch theory narrated by Demirgüç-Kunt and Detragiache (1998).

Additionally, Model 2, 3 and 4 include house prices to reassess the predictive power of systemic banking crises, particularly for a global financial crisis. It was a further aim of this investigation to assess whether the global financial crises might be the outcome of household credit crunch and the theory of liquidity trap by Fisher-Minsky-Koo (see Eggertsson & Krugman 2012). The literature has shown that house price and household debt stood at the highest point prior to the global financial crisis. Therefore, this study includes house price at t-1 and household debt growth at t-1. This is similar to a study by Cerutti, et al. (2017) which clarifies upon three consecutive events before a recession as discussed earlier (i.e. tight link between house price booms and credit, the regular occurrence of house price boom with twin credit boom for firm and household credit and the likelier booms in house price for countries with higher mortgage funding models and loan to value ratios). Finally, the majority of house price booms end up with recession.

The results in Model 2 and 3 present a better model fit and confirm that credit growth to household and house price increase significantly and likelier to precede banking crises. Indeed, positive broad money, change in household debt growth, and real house price reconfirm the liquidity trap theory. During the high inflated price of property followed by high household debt growth, impatient debtors will start to hold their financing and deleverage their borrowings when they perceive that the assets are overpriced, and to cut their consumption. Hence, the low consumption causes the economy to fall under liquidity stagnation or the so-called liquidity trap. Looking at the control variables, GDP growth and depreciation remain significant throughout the models. Inflation was no longer significant as both real credit

growth and house price were included. This does mean the probability of the credit growth and house price outperform inflation in prompting the crisis. Additionally, while banking industries are attentive to credit risk, they enjoy lax lending regulation due to heavy activities in the housing market. Unfortunately, once the asset price collapses, the bank runs out of liquidity, exposing itself to macroeconomic shocks caused by high default which will turn credit into non-performing loans. As such, the accumulation of domestic growth features the crises' likelihood (Alter et al. 2018; Justiniano et al. 2016).

In the next stage, two diagnostic measures were performed on the different specifications for two states; crisis or no-crisis. Following Minoiu et al. (2013) and Comelli (2014), ROC statistic was employed for each estimated model and EWS specification with the largest ROC statistic was selected. The ROC curve interprets a more accurate diagnostic test to differentiate between crises and non-crises based on a larger the ROC statistic. Table 8 depicts that Model 2 and 3 had the largest ROC. For policymakers to decide on the best model, comparing the p-values of ROC statistics was employed with H0 denoting that Model 2 equalled to Model 3. Thus, the probability value was insignificant as it failed to reject H0. Therefore, Model 2 and Model 3 are indifferent.

Figure 1 exhibits the ROC curve, interpreting that the best model would likely approach 1, in which the x-axis denotes sensitivity (i.e. correctly calls for crisis). In contrast, the specificity refers to correctly calls for non-crisis. Thus, Model 3 consistently remains as the best model estimated since the ROC statistic is above 90 percent.

The second diagnostic is in sampling the predictive ability to accurately call crises and non-crises episodes. As shown, the predictive power with a cut-off probability of 0.05 is similar to Demirgüç-Kunt and Detragiache (1998). This predictive power is interpreted as such – the higher the total percentage of correctly calling crisis is better. Model 3 is notably the highest at predicting events of crises with 87 percent of the episodes correctly called. As such, the study determines Model 3 as the best model since it consistently exhibits the correct theoretical assumption and in line with the credit crunch theory. Moreover, the Model 3 has the highest ROC statistic and correctly calls for crisis.

We further examine our models by analysing advanced and emerging economies in split samples to capture any heterogeneous effect for different characteristics of countries depicted in Table 9. The results for advanced economies are consistent with the findings in Table 7. Household debt and the change in household debt show a positive and significantly predictive power in triggering a crisis in Model 1. Model 2 and Model 3 demonstrate that the change in household debt growth had a positive coefficient and significantly preceded the crisis. Moreover, real house price index plays an important role in prompting the banking crises as depicted in all models and estimated with positive sign. In contrast, change in household debt growth has positive probability with banking crises in emerging economies, albeit the change in house price has insignificant links with probability in causing the crises shown in Model 2 and Model 3. The logical explanation behind this estimation result is the list of banking crises in 2008 in emerging countries received little reporting except for Hungary and Russia. Asian countries, in particular, were affected by crises in 1997. According to previous studies around that time, such as that conducted by Corsetti, Pesenti and Roubini (1999), the sharp currency depreciation and investors' panic were reasons for the crises, as demonstrated in Model 3 and Model 4 for emerging economies. Our results are consistent with a recent study by Tunay et al. (2020) which argues that banking crises in emerging economies are likely caused by systemic risk with high credit default. Thus, the effect of house price coupled with household debt is more pronounced in advanced economies.

Overall, Model 2 and 3 present a better model fit with lower AIC in both samples. Additionally, the ROC statistics suggest that Model 2 and Model 3 are appropriate to explain the role of house price and household debt as early warning indicators for systemic banking crises. In reference to the specificity of correctly calls for crisis and non-crisis, both samples obtain about the similar percentage with prior results and demonstrate that the EWS for banking crises model is well explained with the change in household debt and better analysed with the change in house price.

We can conclude that a higher growth in household debt and changes in house prices increase the possibility of banking crises. Consequently, the growth of household debt and changes in house price have significant influence on triggering banking crises, hence worsening the crises in the advanced countries. Additionally, instabilities in macroeconomic factors delay the process of implementing crises prevention policies and worsen the effect of credit shocks as well as asset prices slump, which in turn accentuates liquidity trap. Moreover, macroeconomic changes such as shocks in household income as consequence of job loss may lead to household debt insolvency and spark the crisis. In emerging economies, our results suggest that higher household debt increases the probability of banking crises, followed by currency deprecation as described in the twin crises hypothesis. Thus, the findings from this study may assist policymakers in identifying the probabilities of crises. The EWS may help them to adopt proactive approaches to avoid or reduce the repercussions of systemic banking crises. The findings suggest that policymakers should constantly monitor the changes related to household debt activities as well housing sector as they are important indicators for EWS. In addition, pre-emptive strategies also should be

TABLE 9. EWS Model for Systemic Banking Crises for Advanced and Emerging Economies

Variables	Advanced economies				Emerging economies			
	(1) SBC	(2) SBC	(3) SBC	(4) SBC	(1) SBC	(2) SBC	(3) SBC	(4) SBC
GDPG	-0.299***	-0.304***	-0.305***	-0.210**	-0.218	-0.679*	-0.578**	-0.438**
	(0.100)	(0.109)	(0.108)	(0.096)	(0.189)	(0.347)	(0.240)	(0.207)
OPEN	-0.032	0.026	0.026	-0.019	-0.287*	-0.284	-0.288	-0.247
	(0.052)	(0.054)	(0.054)	(0.057)	(0.173)	(0.295)	(0.216)	(0.172)
DEP	0.041*	0.019	0.019	0.026	0.043	0.084	0.090**	0.063*
	(0.024)	(0.029)	(0.028)	(0.026)	(0.032)	(0.059)	(0.043)	(0.034)
RIR	-0.010	0.062	0.061	0.041	-0.025	0.063	0.004	0.006
	(0.099)	(0.111)	(0.109)	(0.087)	(0.048)	(0.141)	(0.105)	(0.093)
INF	0.034	0.115	0.114	0.228*	0.196***	0.645	0.294	0.233*
	(0.139)	(0.141)	(0.139)	(0.118)	(0.071)	(0.400)	(0.184)	(0.121)
FISCAL	-0.037	-0.014	-0.013	0.012	0.176	0.038	0.178	0.347
	(0.083)	(0.087)	(0.084)	(0.082)	(0.255)	(0.414)	(0.283)	(0.304)
FC	0.007	0.003	0.003	0.005	0.005	-0.023	0.012	0.008
	(0.004)	(0.005)	(0.005)	(0.004)	(0.027)	(0.070)	(0.030)	(0.027)
HD	0.019*	0.001			0.043	0.162		
	(0.011)	(0.013)			(0.039)	(0.121)		
LAG HDTG	0.068***	0.080***	0.080***		-0.006	0.116**	0.072**	
	(0.019)	(0.022)	(0.022)		(0.017)	(0.057)	(0.033)	
LAG HPIR		0.044***	0.044***	0.041***		0.119	0.071	0.047
		(0.015)	(0.013)	(0.012)		(0.077)	(0.051)	(0.040)
Constant	-10.162***	-11.128***	-11.066***	-10.715***	-10.401**	-35.884*	-23.218**	-15.645**
	(3.010)	(3.363)	(3.150)	(2.804)	(4.136)	(19.524)	(9.790)	(7.359)
N	482	454	454	461	281	220	220	224
Pseudo R2	0.2166	0.2811	0.2811	0.1788	0.0822	0.5546	0.4775	0.3269
Log-Likelihood	34.68***	42.58***	42.57***	27.19***	15.33**	22.17**	19.09**	13.12
BIC	187.2163	176.1966	170.0812	180.0484	91.2518	77.14127	74.82867	75.7178
AIC	145.4368	130.8975	128.9003	142.8478	54.86826	39.81136	40.8924	45.01298
ROC statistics	0.8343	0.8732	0.8735	0.8182	0.9254	0.978	0.9757	0.9534
Total correct	19	18	18	18	5	4	4	4
% crises correct	63.16	77.78	77.78	66.67	60	75	75	100
% no crises correct	82.07	83.03	83.26	79.68	94.57	93.52	94.91	93.18
% total correct	81.33	82.82	83.04	79.18	93.95	93.18	94.55	93.3

Probability value respected to significance level in parentheses *** p<0.01, ** p<0.05, * p<0.10

applied for emerging countries pertaining to systemic risk exposure which often transpires with crises.

CONCLUSION

This study has developed EWS for systemic banking crises using household debt as well as house prices as indicators. It estimated the probability of banking crises in 41 advanced and emerging economies using logit models during the period of 1980 to 2018. The results illustrate that as the change in household debt growth increased in tandem with the growth of house prices which may lead to a systemic banking crisis. Other than that, a rise in GDP growth and low inflation could decrease the probability of a crisis. Furthermore, this paper has proven that the two indicators (i.e. tremendous increase in household debt and house price growth) are

critical factors in estimating the probability of a near-future crisis. The evidence is consistent for advanced economies while the change of household debt may precede crises in emerging economies but not together with a change in house price. Hence, the findings are very useful for the involved authorities to monitor the environmental changes taking place in household debt and house prices to reduce the economic shocks that may lead to banking crises. It is suggested for future research to take into account other factors relating to institutional quality as early indicators for EWS model in predicting banking crises.

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