Modern recession forecasting systems: The signals approach

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Abstract: *Global recession fears have been rising with the worldwide outbreak of the COVID-19 pandemic. Could we have predicted the outcomes of the events that led up to the current liquidity crisis? Could economic indicators potentially forecast recessions? If yes, what are those indicators, and how should average people interpret them?*
This work aims to create a crisis prediction model as an independent forecasting system for giving an estimation of the likelihood of a recession. To establish the connections between indicators of financial stability, we represent a literature review. Then the operability of these indicators and their updated thresholds are analyzed for the European market. To determine the effectiveness of the chosen indicators, we used the "Signals Approach" method. In the end, the results are presented and discussed. This article generally describes quantitative indicators. Further analysis is needed to make a conclusive statement about the economic condition.
Keywords: *recession, forecasting system, financial indicators, Signals Approach.*

1 Introduction

The COVID-19 pandemic has stopped a 10-year growth streak in equities markets and brought them down to prices of pre-2008 levels [1]. The twin shocks simultaneously hit the global economy in the form of a major disruption of supply chains. A massive shift in the supply-demand curve of energy resources has been seen; the 30% overnight drop in the price of oil because of a newly emerging Saudi Arabian-Russian price war has driven the global economy to a standstill [2]. Most of the business has, on average, roughly from 17 to 30 days until they entirely run out of money, so they will be forced to file for bankruptcy [3]. The notorious "fear index" (VIX) that measures market risk is likely to bring significant contributions to future market selloffs and growing distrusts in the equities markets [4]. Most of Europe's leading economies now charge negative interest rates on the bonds, basically meaning that the investors pay for the borrowers to hold their money [5]. The toll that the coronavirus pandemic has on the European economy is going to be the greatest in Italy, with GDP growth

nearing -3.4 percent [6]. By the end of the first-quarter GDP growth is expected to be 0,1 % and one of the most important economic indicators in a country, the trade balance, is likely to contract by an enormous 20 billion euros, introducing a trade deficit [7].

Should the pandemic be longer than estimated, or should the protective measures imply to fight the virus fail to achieve substantial results? Researchers have concentrated on creating models that would be capable of foreseeing economic instability and correspondingly react to it based on its intensity and spread.

This work aims to gather a database of all the possible banking and currency crises indicators, evaluating their feasibility, and, if viable, model their behavior. The contribution of a currency or banking crisis prediction model would be that of an independent forecasting system that would give an estimate of the recession likelyhood. To establish connections between particular indicators of financial stability, we represent a brief literature review. Then, operability of the indicators and their updated thresholds are analyzed for the European market. To determine the effectiveness of the chosen indicators, we applied the "Signal approach" methodology. The results of the proposed method for financial stability analysis are evaluated and discussed. This research is limited by the study of the sole indicators determined here. Our conclusions and future work are drawn in the end.

2 Related work: Financial stability indicators

Economic security can be characterized by a state of financial institutions where the protection of national interest is guaranteed, altogether with a socially oriented development of the country as a whole [8]. Fisher proclaims that instability is closely correlated with macroeconomic cycles, in particular, with the dynamics of the so-called "big debt crises" [9], also defined by Dalio [10]. To identify threats, determine the accumulating and potential disbalances, early warning systems were developed. Financial crises are likely to result in an indirect loss in the form of a decline in the GDP. From 1973 to 1997, in roughly 70% of the cases, banking, or currency crises were followed by economic crises [11]. In 58 out of the 113 financial crisis episodes that happened from 1980 to 2007, a significant decline in economic growth, or a more severe recession was observed [12]. Economic crises followed by financial crises have culminated in a cumulative reduction in the GDP in a range from 7.6 to 13.8%.

The authors of the neoclassical paradigm studying the possibilities of forecasting models since the 1990s put forward an ambitious, original, hopeful, and refreshing idea [13], [14], [15]. They contributed to synthesizing different methods of forecasting economic crises and creating an early warning system that will be relevant, looked up upon, and used not only by politicians and economists but by average people as well. Nonetheless, the analysis of the construction of such early warning systems around international developed economies shows that the majority of these indicators fail to predict crises around half of the time. This,

however, doesn't stop the social-sciences community from developing a secure and well-trusted approach toward the risk evaluation of pre-crises episodes. The absence in Europe, and in particular in Hungary of an effective early crisis warning system highlights the relevance of analyzing international experience in this sphere.

To predict crises events, several methods can be used, from logit models, Markov switching models to unique individual models developed by Nobel-prize winning economists [16]. The evaluation of the frequency of choosing a specific crisis forecasting method is explained by Yucel [17]. The first and most complex step to build an early warning system is to select a small quickly updating simple to interpret list from a vast array of possible economic indicators that would predict crisis periods in advance, with some probability [18], [19]. The difficulty of choosing the proper macro indicators manifests itself not only in the lack of information, or in its quality but also the uniqueness of each crisis. Blindly following the experience of the international community may be troublesome, as each country has its geopolitical role and level of development. All of these problems resulted in a broad discussion [13], [18].

Eichengreen, Frankel, and Wyplosz have studied the regularities of the dynamics of indicators [20], [21], [22]. In their works, they applied a graphical approach that provided rich and structural analysis to be conducted regarding the behaviors of variables on the currency. Frankel showed that parameters in the identification of currency crises could be determined in four groups: indigenous variables, exogenous variables, variables characterizing national debt, and the outside economic condition [21], [22]. Banking crisis signaling indicators (in the group of the internal macroeconomic policy), international economic conditions, internal financial structure, currency exchange rates, were found to be successful in the predictions of crises based on the data in the work of Edison [23]. To examine the correlation between the two types of crises (banking and currency), Kaminsky and Reinhart analyzed the indicators that showed levels of financial liberalization in countries, development of monetary sectors, and fiscal variables [15]. Aziz and Caramazi examined the crises episodes from 1975-1997 in developing countries, and they found a set of base indicators such as currency exchange rates, export, terms of trade, inflation, M2 reserves, and global interest rates [24].

Other authors concluded that the probability of a crisis grows as the M2 supply of gold and foreign currency reserves decreases [13]. Similar dazzling and unobvious theories [25] have arisen from the work of Oviedo [26]. His results showed there is a direct correlation between the cyclicality of economies and interest rates. Lower interest rates are tied to periods of economic growth; during these periods, the probability of a crisis emerging is the lowest. The dependence of crisis' situations and interest rates is also explored by the researchers [27].

Kaminsky suggested to include the index of volatile sock markets into the set of crisis forecasting indicators [15]. Russian economists devoted to finding

statistically meaningful indicators [28], [29]. It was concluded that GDP growth rate, gold and foreign currency reserves, the real exchange rate, current account balance, export, internal debt, real interest rates, inflation, outflow of capital, M2 supply and terms of trade, have with the highest predicting power and the lowest uncertainty boundary. One of the most accurate indicators featured in topics related to early warning system crisis prediction models is the exchange rate of the domestic currency. Low gold and foreign currency reserves is also regarded as a popular indicator of a potential future crisis. The inability to cover short-term expense obligations from the reserves of the central bank could provoke speculative attacks on the national currency [25]. A high external or internal debt to GDP ratio of the government is almost always a cause for alarm in the financial sector. Same as the rapid rise in M2 supplies. Adverse shocks on important stock markets also increases the chances of financial instability reappearing in the whole economy.

Regarding Kumar, trade integration can be considered as a crisis indicator [30]. Fedorova emphasized financial and trade channels during the 2008 crisis and analyzed the concept of channels where crises could spread [31]. To introduce the trade integration index, Kumar puts forward the idea of export correlation coefficient [30]. Nitschka defines it as a financial integration index inferred from the cross-correlation coefficient of stock indices [32]. The financial liberalization crisis indicator has proven to be accurate at the 99% level for the crisis events from 1980 to 2002 [25]. The authors put forward unemployment level indicators, which have worked on 95% levels [33]. Some authors regard these economic indicators as simply risk indicators, expressed through the parameters of GDP volatility, rise in credit provision, trade, inflation, etc. Depending on the specifics of the countries or economic communities' peculiarities, an advised base set of predetermined and precalculated indicators can be added to or redacted from [25].

3 Methodology

The procedure for determining the cumulative predictive power of any given indicator varies from research to research. Some methods could potentially yield the same results regarding the predictive power, in which case the one that is generally easiest to use is applied. As it was mentioned above, the procedure involves a set of actions by which a formal macroeconomic indicator is turned into a signaling one. When that specific newly composed signaling indicator's value gets below, or over a certain pre-determined threshold level, it would produce an interpretable signal, by which the indicators predictive power could be measured. First, let's view a time-series graph of an economic indicator. For instance, it could be a quarterly report of national GDP growth, or it could also be a composite of several indicators with a linear or nonlinear dependence $X = X(T_i)$, where X is the value of the indicator at the time T_i (Figure 1).

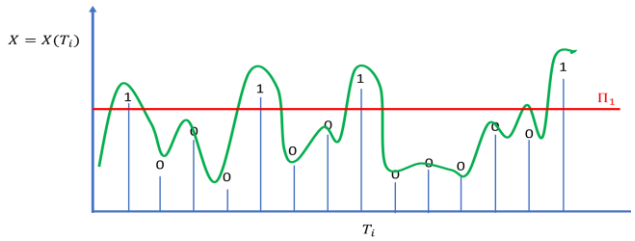

Figure 1

Binary Crisis indicator time-series graph analog. Created by the authors.

To determine that specific indicators correlation with a binary crisis indicator, we need to construct the latter. The construct will feature a variable that will be projected on the time axis, and it will move between two distinct values: (0- indicating that there is no crisis, and 1- meaning that there is a crisis) (Figure 2) [13].

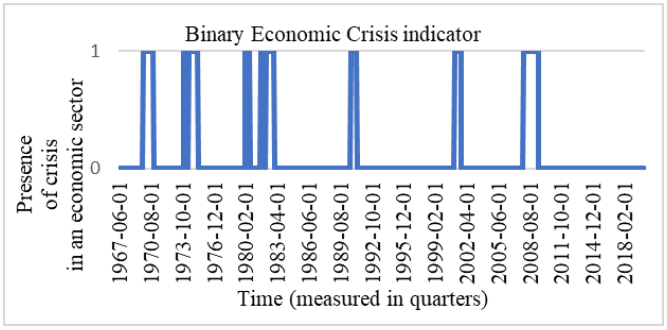

Figure 2

Binary indicator of the presence of crisis. Created by the authors. Referred to: Piger, Jeremy Max and Chauvet, Marcelle, Smoothed U.S. Recession Probabilities [RECPROUSM156N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/s , Additional conditions - if crisis probability is higher than 20 % than an economic recession has started.

The next step is to create a threshold signaling indicator from the ordinary economic indicator defined in the first step. We, therefore, declare an arbitrary threshold Π_1 and state that if in the moment of observation T_i the X variable of the $X = X(T_i)$, indicator exceeds the Π_1 threshold, then the indicator worked, and it can be concluded that it gave off a signal, which the observer interprets as 1. If, however in the moment of observation T_i the value of X didn't exceed the arbitrary Π_1 threshold, then we interpret the signal as 0. That's why this signaling indicator is often regarded as a binary indicator (Figure 1). The functioning of the indicator, in itself, is considered as a random event, and X_i is indeed a random

value. we extend our observations towards the full available time horizon of the given database of the now transformed signaling threshold indicator and find out whether any financial instability had occurred during the first three to six months'

as the signal, at the moment T_i was produced. Subsequently, it is concluded that there are four possible outcomes of the observation, they are presented in the following logic (Table 1):

Table 1

Logic Table of the possible outcomes

	Crisis Present	**Crisis Absent**
Signal Triggered	A	D
Signal isn't Triggered	C	B

The sum of A+B+C+D must be equal to N, where N must, therefore, be a large number for the feasibility of the study to be optimal. It can thus be stated that the sets of possible occurrences do not intersect. First, we calculate the probability of the crisis:

$$P(F)=\frac{A+C}{N} \quad (1)$$

Secondly, we calculate the probability that the crisis occurred given that the indicator produced a signal- (the event of the indicator being triggered giving off the signal is defined by the letter S):

$$P(F/S)=\frac{A}{A+B} \quad (2)$$

If the indicator mostly sends "good" signals, then it can be expected that the probability of financial instability occurring given that $P(F/S)$, meaning that the signal was produced will inevitably be more than the unconditional probability of $P(F)$ [11], [25], so the following relationship must hold: P(F/S)>P(F). The most important requirement that has to be met is that the number of correct signals of the indicator must be more than the number of false signals. To measure this, we need a so-called unfitness coefficient *K*. It would be equal to the relation of the conditional probability of the event of the crisis not occurring (this event shall be defined in an equation by the letter *G*) given that the indicator was triggered (S) to the conditional probability of the crisis event occurring given that the indicator gave off the correct signal:

$$P(G/S)=\frac{B}{B+D} \quad (3)$$

The equation for the K coefficient is as follows:

$$K=\frac{P(G/S)}{P(F/S)} \quad (4)$$

The smaller the coefficient K, practically the closer it is to zero, the better the threshold signaling indicator is. Some researchers [11], [13], [25] indicate another way to determine the quality of the indicator:

$$P(C)=\frac{A}{A+B} \quad (5)$$

The choice of indicators and their transformation into signaling ones depends on highly unpredictable variables. As an example, some scientist introduces additional variables like $P(C)$ to measure the predictive power, these variables in themselves are of arbitrary nature, and besides, as the situations, progress may need additional recalculation. Economists also explain their choice of $P(C)$ over the K coefficient by the fact that theoretically, this K coefficient equal to zero.

This reasoning outlines the algorithm for choosing the Π_i threshold for our signaling indicator described in the next section.

4 Results and discussion

As a means of establishing the most optimal objective and unbiased solution to finding the best signaling threshold indicator, we acted in accordance with the following steps:

Step 1: We draw a number of thresholds, each separated from another by a certain predefined constant interval that we shall define as Δ- Delta (Figure 3).

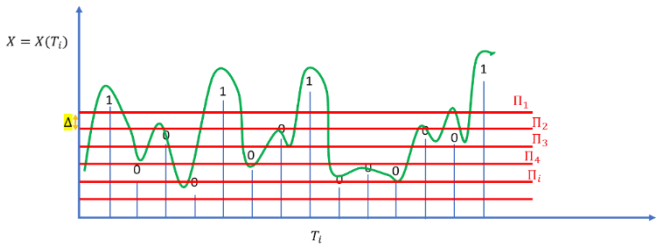

Figure 3

Threshold indicators graph analog. Created by the authors.

Step 2: We choose an arbitrary threshold Π_0 and create a table of observations for this threshold following the logic table (Table 1).

Step 3: Determining the $P(F)$.

Step 4: Determining the $P(F/S)$.

Step 5: Checking the necessary condition whether $P(F/S) > P(F)$. If the condition is met, we move on to the next step. If it's not, then it is concluded that the economic indicator X with the threshold level of Π_0 is a weak threshold signaling indicator, so we go back to the threshold, picking step 2.

Step 6: We calculate the K coefficient for the given threshold. Then, we note K as K_0 and we record it. We move on to the next step.

Step 7: We take another arbitrary threshold Π_1 that is of a predefined Δ-distance away from the previous one, and we go through steps 3,4,5,6 and record the specific K_1coefficient.

Step 8: We do this process for all of the Π_i thresholds and determine each coefficient K_i.

Step 9: We highlight the thresholds where K =0, or as small as possible, and from these threshold levels, also pick the one that yields the highest $P(C)$ value. This will be the optimal threshold level of Π (Figure 4).

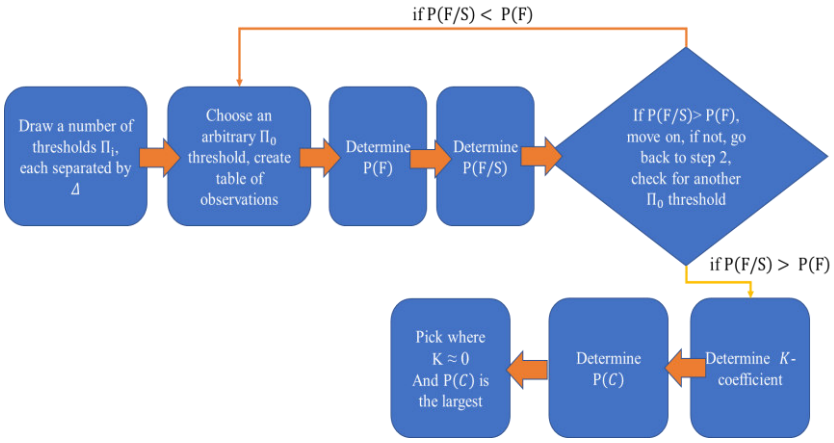

Figure 4

Visualized block scheme of the algorithm of choosing the threshold levels of a signaling indicator.

Created by the authors

To satisfy the incentive of creating an automatization of the algorithm above, a program coded in MATLAB was used.

From the values retrieved as a result of the operation of the program, we choose that threshold, for which the MinK is the smallest of the three and the P(F/S) is the largest.

We suggest that the program should be used for many time series of economic indicators to find the best suiting ones. The limitations of the signaling method manifest themselves in the probabilistic nature of the prediction system. So, there is an inherent element of utter chance that with a 99.9 percent confidence level of making a type 2 mistake, there is still a chance that a crisis occurs while still not being considered as a "black swan". The disadvantage of using a discrete binary variable as an explaining indicator in the predictive power determination algorithm is that it is based on historical data, which is often unreliable, depending on the country, meaning that it's not quite accurate or applicable in their case.

Conclusions

Among the numerous ways of finding financial instability indicators presented in the corresponding section above, it was discovered that most of them heavily rely on subjective opinions, assumptions, outdated ideas inapplicable for modern monetary policy, and data of questionable quality and origins. Therefore, this reasearch paper aimed to introduce an objective way of analyzing signaling indicators and finding an algorithm for determining the best fitting one for crisis prediction purposes and enhance it with a program. The advantage of the application would be that of an independent forecasting methodology. The disadvantages of the method are slight. However, they are inherent to the model. As the program is going to develop, it will be enhanced with Machine learning and AI technologies to make more accurate evaluations of the signaling indicator.

References

[1] "RIP to the Longest Bull Market in History (2009-2020) | The Motley Fool." [Online]. Available: https://www.fool.com/investing/2020/03/12/rip-to-the-longest-bull-market-in-history-2009-202.aspx. [Accessed: 26-Jun-2020].

[2] "What's behind Saudi Arabia's oil price war with Russia? | Saudi Arabia | Al Jazeera." [Online]. Available: https://www.aljazeera.com/programmes/countingthecost/2020/03/saudi-arabia-oil-price-war-russia-200315114308947.html. [Accessed: 26-Jun-2020].

[3] JPMorgan Chase & Co., "Cash is King," 2016. [Online]. Available: https://www.jpmorganchase.com/corporate/institute/document/jpmc-institute-small-business-report.pdf.

[4] "Inside Volatility Trading: March 24, 2020." [Online]. Available: https://www.cboe.com/blogs/options-hub/2020/03/24/inside-volatility-trading-march-23-2020. [Accessed: 17-Jun-2020].

[5] K. Martin, "Year in a word: negative yields," 2019. [Online]. Available: https://www.ft.com/content/2bcbc132-1c12-11ea-9186-7348c2f183af. [Accessed: 17-Jun-2020].

[6] Alphaville, "Markets-Now," 2020. [Online]. Available:

http://ftalphaville.ft.com/2020/03/17/1584439394000/Markets-Now---Tuesday-17th-March-2020/.

[7] "European Union GDP Growth Rate | 1995-2020 Data | 2021-2022 Forecast | Historical." [Online]. Available: https://tradingeconomics.com/european-union/gdp-growth. [Accessed: 17-Jun-2020].

[8] В. К. Сенчагов, *Экономика, финансы, цены : эволюция, трансформация, безопасность*. Moscow, 2010.

[9] I. Fisher, *The Debt-Deflation Theory of Depressions*. 1933.

[10] R. Dalio, *Principles for navigating big debt crises*, First edit. Westport CT: Bridgewater, 2018.

[11] A. Ulyukaev and P. Trunin, "Application of a signals approach to the development of early warning indicators of financial instability in the Russian Federation," *Stud. Russ. Econ. Dev. - Stud Russ Econ Dev*, vol. 19, pp. 516–522, Sep. 2008.

[12] R. Cardarelli, S. Elekdag, and S. Lall, "Financial stress and economic contractions," *J. Financ. Stab.*, vol. 7, pp. 78–97, Jun. 2011.

[13] A. Demirguc-Kunt and E. Detragiache, "The Determinants of Banking Crises in Developing and Developed Countries," *IMF Staff Pap.*, vol. 45, p. 3, Mar. 1998.

[14] G. L. Kaminsky and C. M. Reinhart, "On crises, contagion, and confusion," *J. Int. Econ.*, vol. 51, no. 1, pp. 145–168, 2000.

[15] G. Kaminsky, S. Lizondo, and C. Reinhart, "Leading Indicators of Currency Crises," *IMF Staff Pap.*, vol. 45, no. 1, pp. 1–48, 1998.

[16] M. Marcellino, "Chapter 16 Leading Indicators," *Handb. Econ. Forecast.*, vol. 1, no. 05, pp. 879–960, 2006.

[17] E. Yucel, "A Review and Bibliography of Early Warning Models," Aug. 2011.

[18] С. С. Шумська and Р. України, "Економіка в умовах сучасних трансформацій," *Економіка в умовах сучасних трансформацій*, pp. 26–43, 2010.

[19] G. A. Calvo, "Balance of Payments Crises in a Cash-in-Advance Economy," *J. Money, Credit Bank.*, vol. 19, no. 1, pp. 19–32, Jun. 1987.

[20] B. Eichengreen, A. K. Rose, C. Wyplosz, B. Dumas, and A. Weber, "Exchange Market Mayhem: The Antecedents and Aftermath of Speculative Attacks," *Econ. policy a Eur. forum*, vol. 10, no. 21, pp. 249–312, Oct. 1995.

[21] J. A. Frankel and A. K. Rose, "Currency crashes in emerging markets: an

empirical treatment," *Int. Financ. Discuss. Pap.*, vol. 41, no. 3–4, pp. 351–366, 1996.

[22] J. A. Frankel and A. K. Rose, "Currency Crashes in Emerging Markets: Empirical Indicators," National Bureau of Economic Research, Inc, Cambridge, Massachusetts, 2000.

[23] H. Edison, "Do Indicators of Financial Crises Work? An Evaluation of an Early Warning System," *Int. J. Financ. Econ.*, vol. 8, pp. 11–53, Feb. 2003.

[24] R. Salgado, J. Aziz, and F. Caramazza, "Currency Crises: In Search of Common Elements," 2000.

[25] Е. А. Фёдорова and И. Я. Лукасевич, "Прогнозирование финансовых кризисов с помощью экономических индикаторов в странах СНГ," *Проблемы прогнозирования*, vol. 2, pp. 112–121, 2013.

[26] P. M. Oviedo, "Macroeconomic Risk and Banking Crises in Emerging Market Countries: Business Fluctuations with Financial Crashes," in *Federal Reserve Bank of San Francisco Proceedings*, 2004.

[27] P.-O. Gourinchas, R. O. Valdés, and O. Landerretche, "Lending Booms: Latin America and the World," *Econ. J.*, vol. 1, no. Spring 2001, pp. 47–100, 2001.

[28] Е. Т. Gaidar, "Экономика переходного периода [Текст] : сб. избр. работ, 1999-2002," in *Ин-т экономики переход. периода ; редкол*, Moscow, 2003, pp. 299–365.

[29] П. В. Трунин and М. В. Каменских, *Мониторинг финансовой стабильности в развивающихся экономиках: (на примере России)*. ИЭПП, 2007.

[30] M. Kumar, U. Moorthy, and W. Perraudin, "Predicting Emerging Market Curency Crashes," *J. Empir. Financ.*, vol. 02, pp. 427–454, Feb. 2003.

[31] E. Fedorova and O. Bezruk, "The channels of financial crisis transmission in emerging markets," *Vopr. Ekon.*, no. 7, pp. 120–128, Jul. 2011.

[32] T. Nitschka, "About the soundness of the US-cay indicator for predicting international banking crises," *North Am. J. Econ. Financ.*, vol. 22, no. 3, 2011.

[33] T. Komulainen and J. Lukkarila, "What drives financial crises in emerging markets?," *Emerg. Mark. Rev.*, vol. 4, no. 3, pp. 248–272, Apr. 2003.