

Early Warning System and Crisis Management

Ririn Riani¹, Ihsanul Ikhwan²

¹SMART Indonesia

²IIUM University, Malaysia

This research was made to find out the development map on the research topic with the theme Early Warning Economic Crisis. This study discusses bibliometric mapping of the development of trends in keywords, authors, and journals on digital banking from a number of Scopus-indexed reputable papers published between 1990 and 2021. Early warning systems help organizations reduce losses and are critical in detecting emergencies from occurring. This research contributes to the field of early warning system development and applications in the economic and financial sectors by providing new knowledge and critical insights into a previously unexplored topic. Our research also contributes to a better understanding of the use of Early warning systems in business, finance, and economics. Consequently, accumulating knowledge to detect risks before it is too late is crucial for companies to maintain a competitive advantage in the market.

Keywords: Early Warning System; Economic; Crisis Management

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*Correspondence:

Ririn Riani

ririnrianismart@gmail.com

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INTRODUCTION

The global economy has experienced many financial crises in the last decade, with often devastating and catastrophic economic, social and political consequences. The Latin American crisis of 1994-1995 and the Asian financial crisis of 1997-1998, severely affected a large number of countries and had systemic consequences for the world financial system as a whole. Given the high costs incurred by economies during financial crises, the threat that multiple crises may pose to the global financial system, and the perception that there may be common elements underlying financial crises, researchers have concentrated on developing models that can assist policymakers in anticipating problems and responding appropriately.

Financial crises have a significant effect on the economy, especially in terms of loss of output, and the impact often spreads to other economies. (Edison, 2003). It is suspected that a strong influence on the various crises that have occurred is due to policy imbalances such as unsustainable fiscal and monetary factors, which cause misalignment of asset prices, especially exchange rates. As a result, since then, international organizations as well as private sector institutions have started to create Early Warning System (EWS) models to predict if and when individual countries could be affected by a financial crisis. (Bussiere & Fratzscher, 2006).

Empirical studies on the construction of Early Warning Systems for financial crises usually use one of the two techniques. The static signal extraction strategy was coined by Kaminsky et al. (1998), a non-parametric method that involves searching for and monitoring certain variables that tend to behave atypically in the face of financial or economic difficulties. If these indicators exceed a specified threshold value, calculated as a specific percentile of each indicator's sample distribution, the model is designed to flag an imminent disaster. Casu et al. (2012) suggest a dynamic threshold selection method that focuses more on indicator volatility. They define the threshold as a number of standard deviations from the long-term mean of the variable. With exceptions, no techniques have been used for modeling Early Warning System for sovereign default, despite the fact that static approaches were made in the context of currency crises and dynamic approaches for detecting banking crises (Savona and Vezzoli, 2015).

Today, the rapid spread of the COVID-19 virus has caused a health crisis that has led to a severe

economic crisis. This ultimately reveals that pandemic warning systems at local, national and international levels are woefully inadequate. (Fearnley & Dixon, 2020). By 2030, one of the seven goals of the worldwide framework is to significantly expand the availability and accessibility of multi-hazard early warning systems, and disaster risk information and assessment. In the case of the COVID-19 pandemic, it is too late to establish a standardized Early Warning System across borders, but an assessment of the success factors in the warning systems adopted by countries would be helpful. To create and manage a successful Early Warning System for government agencies that will use it to activate protocols, experts from all disaster management disciplines, including epidemiologists and mathematicians, must be brought together to meet this need. Early Warning Systems will also be needed in our interconnected society beyond the current COVID-19 crisis (Himmler et al., 2021).

As a result of the many dynamic changes in the economic structure that always fluctuate, causing various changes in conditions beyond prediction. It is necessary to have a strategic plan and build a standardized Early Warning System in order to mitigate the occurrence of various risks that can exacerbate the crisis, therefore, research on the topic of Early Warning Economic Crisis is a very important topic to discuss today. This research is made to see how far the development trend of research on the topic of Early Warning Economic Crisis is carried out. Furthermore, the research will discuss the bibliometric mapping of the development of trends in keywords, authors, and journals on digital banking from a number of Scopus-indexed reputable papers published between 1990 and 2021. Furthermore, the research will examine these findings to review matters related to the Early Warning System and its relation to the Crisis Indicator.

LITERATURE REVIEW

Currently, the literature on business cycle theory is based on the notion of dynamic stochastic general equilibrium and reflects the trajectory of economic development (Lang & Yang, 2019). The general equilibrium in the modeled economy is formed by the adequate response of representative economic agents to current conditions, taking into account all possible expectations. Consequently, in the real-cycle model, the general equilibrium is stochastic, and the actual dynamics of economic development is governed by random shocks (Semin et al., 2020). In other words, the business cycle is the result of random or

unexpected shocks. This implies that crises cannot be predicted based on a specific sequence of events. The core idea of the economic cycle analysis approach is that if the trajectory is in equilibrium, fluctuations in basic macro indicators are stochastic. As a result, they began to study not the macroeconomic series but their dispersion.

A theory emerged at the turn of the twentieth century on the Credit and Monetary Cycle Theory, which described crises as disruptions of the monetary cycle (Hawtrey, 1926). The most comprehensive presentation of this idea, that credit and monetary policy variables were significantly responsible for the crisis. He blamed banks for restricting lending (countercycle behavior), which in turn reduced corporate activity and led to the economic crisis. It should be emphasized that a number of scientists believe that financial crises are the main cause of economic downturns. According to research conducted between 1973 and 1997, financial crises were followed by economic crises 70 percent of the time. If currency and banking crises occur simultaneously, then a very severe economic disaster will occur.

One of the most pressing issues in the study of financial crises is to develop integral indicators that can be used to predict periods of financial instability. The global financial crisis of 2008, which prompted the emergence of a large number of integral crisis indicators. The process of establishing complex systems for monitoring financial markets and early warning of crisis phenomena continues to be developed, by several international financial organizations, such as: IMF, World Bank, IOSCO (International Association of Securities Commissions), Bank for International Settlements (BIS) and the Financial Stability Board (FSB) under the G20. (Semin et al., 2020).

The existing literature divides Early Warning Systems into two categories: macro-level indicators and micro-level indicators. In the first group, some researchers analyze using macroeconomic factors such as GDP growth, interest rates, inflation, and exchange rates. For example, Kaminsky et al. (1998) investigated 26 banking crises and 76 currency crises over the period 1970-1995. They examined 16 possible indicators, including trade, real exchange rate, and reserves, as well as real and fiscal sector trends, and the degree of financial liberalization. They found that the variables of real exchange rate, stock prices, and public sector deficit to GDP were the three most influential indicators. Furthermore, Demirgüç-Kunt and

Detragiache (1998) investigated 65 economies between 1980 and 1994. They took into account macroeconomic variables such as real GDP growth, real interest rate, and inflation rate, as well as financial variables such as money supply to reserves and real credit growth rate, real GDP per capita and deposit insurance variables. They claim that low economic growth, high inflation and high interest rates are all associated with banking crises. Most subsequent studies have followed these two studies in terms of indicator selection.

Furthermore, studies have approached micro-level variables such as bank capital, liquidity, and default risk. For example, Barrell et al. (2010) using a logit model for 14 OECD countries, they suggest that the Early Warning System for financial crises is usually closely related to bank capital, bank liquidity, and property values. They found that capital adequacy, liquidity ratios, and property prices all have a large influence on banking crises. Wong et al. (2010) further developed an Early Warning System for financial problems. They highlighted key indications of economic financial distress such as default risk assessment derived from bank-level data, credit risk of banks and non-financial firms, asset price differentials, macroeconomic credit expansion, currency crisis vulnerability, and the occurrence of stress in other countries, are all important key indications detected as indicators of financial crisis.

METHODOLOGY

This research uses other research journals from 1990-2021 related to *Early Warning Economic Crisis*. These journals are obtained or accessed *online* from published journals. The methodology used in this research is a qualitative method approach with descriptive statistics of literature studies on 371 publications related to the *Early Warning Economic Crisis*. Qualitative research method is a research method based on the philosophy of postpositivism which is used to research on natural object conditions, (as opposed to experiments) where the researcher is the key instrument. Data collection techniques are triangulated (combined), data analysis is inductive / qualitative, and qualitative research results emphasize meaning rather than generalization (Sugiyono: 2008).

Then, this research is followed by bibliometric analysis. Bibliometric studies in information science are studies that can reveal patterns of document utilization, literature development or information sources in a subject area. Bibliometrics includes two types of

studies: descriptive studies and evaluative studies. Descriptive studies analyze the productivity of articles, books, and other formats by looking at authorship patterns such as the gender of the author, the type of work of the author, the level of collaboration, the productivity of the author, the institution where the author works, and the subject of the article. Evaluative studies analyze the use of literature created by counting references or citations in research articles, books, or other formats (Pattah, 2013).

Qualitative research is descriptive. The data analyzed is not to accept or reject hypotheses (if any). The results of the analysis are in the form of a description of the symptoms observed and do not have to be in the form of numbers or coefficients between variables (Subana and Sudrajat: 2005). According to Wijaya (2013), descriptive statistics is a field of statistics that studies ways of collecting, compiling and summarizing research data. The data must be summarized properly and regularly, either in the form of tables, diagrams or graphic presentations, as a basis for various decision making (Wijaya: 2013).

This research uses a *purposive non-probability sampling* method. *Purposive* samples are samples that have the aim of understanding certain information. This sample can be grouped into decision samples (*judgment*) which select sample members according to certain criteria on the basis of past records or research objectives to be achieved, and quota samples, where the sample is selected based on a certain quota or category, which describes the dimensions (proportions) of the population (Wijaya: 2013). The criteria referred to in this study are 873 publications related to the theme of *Digital Banking* in the period 1996-2021.

Then these journals were analyzed using VOSViewer *software*. VOSviewer is a program we developed to build and view bibliometric maps. It is freely available to the bibliometric research community (see www.vosviewer.com). VOSviewer can display maps in many different ways, each emphasizing a different aspect of the map. It has functions for zooming, scrolling, and searching, which facilitate detailed examination of the map. The display capabilities of VOSviewer are particularly useful for maps that contain at least a large number of items (e.g., at least 100 items).

To build the maps, VOSviewer uses the VOS mapping technique (Van Eck and Waltman 1996a),

where VOS stands for visualization of similarity. For previous studies where the VOS mapping technique was used, we refer to Van Eck and Waltman (1996b) and Van Eck et al. (in press). VOSviewer can display maps constructed using the corresponding mapping technique.

RESULT AND DISCUSSION

Bibliometrics Analysis

Bibliometric Graph Analysis

Bibliometrics is based on the calculation and statistical analysis of scientific output in the form of articles, publications, citations, patents, and other more complex indicators. It is an important tool in evaluating research activities, laboratories and scientists, as well as scientific specialization and country performance. The report, after setting the background to the development of bibliometrics, presents the databases on which bibliometrics is built, as well as the main indicators used.

To explore the results of the meta-analysis, this section will present a visual mapping chart of 371 journals published on the theme of *Early Warning Economic Crisis*. The results of the keyword mapping analysis become the basis for mapping together important or unique terms contained in a particular article. Mapping is a process that allows one to recognize knowledge elements and their configurations, dynamics, interdependencies, and interactions.

Related to bibliometrics, science mapping is a method of visualizing the field of science. This visualization is done by creating a landscape map that can display the topics of science (Royani, et al., 2013). The results of network visualization of 371 word map journals with the theme of *Knowledge Management* can be seen:

Co-Authorship Analysis

Furthermore, bibliometric results will be displayed based on sub-themes, namely authors, organizations, and countries.

1. Co-authorship Authors

Using VOSViewer software, we found the bibliometric mapping of authors as shown in the following figure. The larger the shape and the brighter the color indicates that the author has published more papers related to *Early Warning Economic Crisis*.

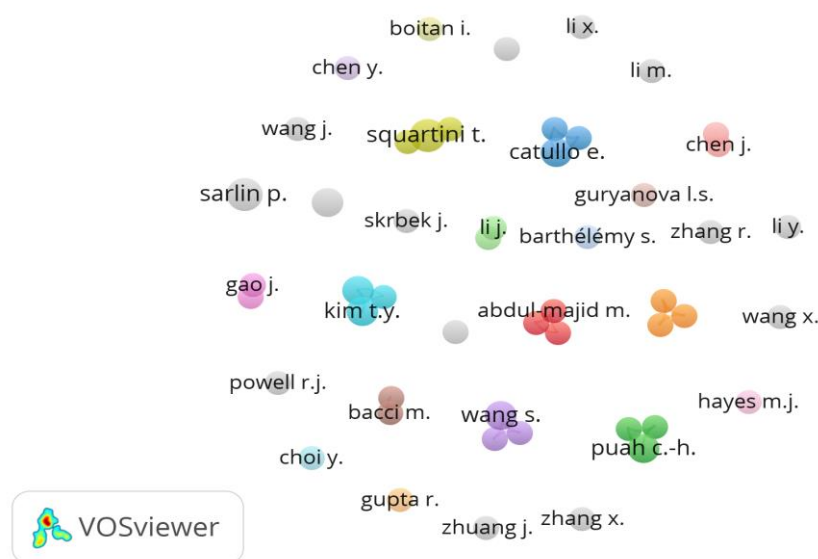


Figure 1. Co-authorship Authors

The display of cluster density depends on the level of light description. This identifies that the color on the map depends on the number of items associated with other items. This section is useful to get an idea of the general structure of the bibliometric map by noting which parts of the light are considered important to analyze. From the map, it is possible to interpret the authors who published the most.

In general, each researcher has different tendencies. Some write indexed as a single author, others write together with other researchers so that several clusters appear which are indicated by different densities. However, authors whose density is quite large show that they publish more research on the theme of

Early Warning Economic Crisis compared to those with lower density, so these results can be used as a reference for future researchers.

Based on these results, the bigger and brighter the author's name, the more papers he published. The author who published the most publications related to the theme of *Early Warning Economic Crisis* based on bibliometric mapping, namely *Squartini T.*

2. Institutional Co-authorship (Co-citation)

In bibliometric analysis, the author's institution can be seen from which institution they come from. Through this result, we can interpret the institution that wrote the most publications.

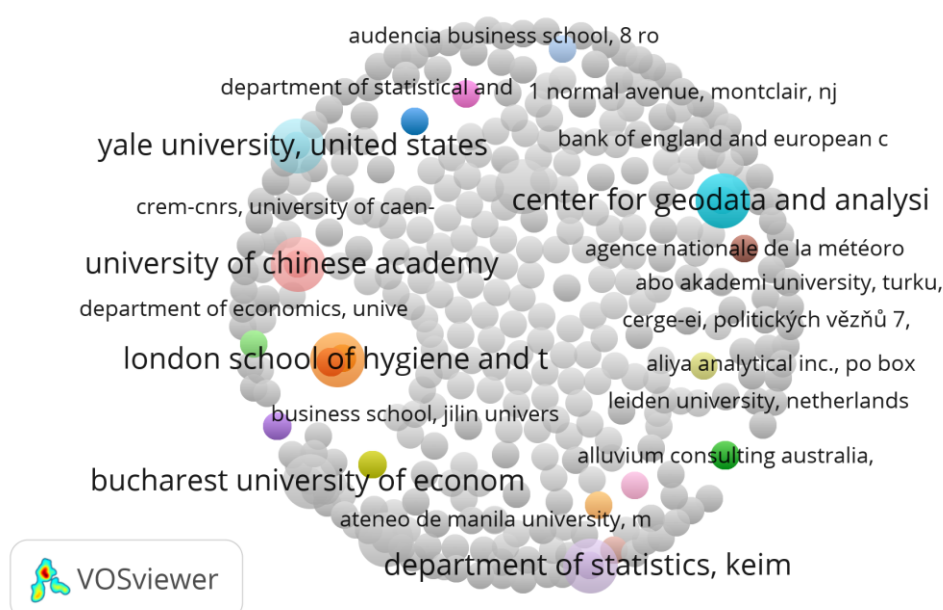


Figure 2. Institutional Co-authorship (Co-citation)

Based on the following figure, clusters of institutions seen with glowing circles indicate how productive the institution is in contributing to publishing papers on the theme of *Early Warning Economic Crisis*. The largest number of institutions is calculated from the number of publications and the number of links to other institutions, where an author can write many papers in different journals.

The most popular institutions are calculated based on the number of publications and the number of links to other institutions, where a paper author may

write multiple papers in different journals. The most famous institution ranking shown by the bibliometric mapping results is the *Center for Geodata and Analysis*.

3. Co-authorship Country

Furthermore, the visualization of journal publisher mapping is depicted in the bibliometric image of journal sources below. Based on this figure, we can see several country clusters that appear to publish the most articles with the theme *Early Warning Economic Crisis*.

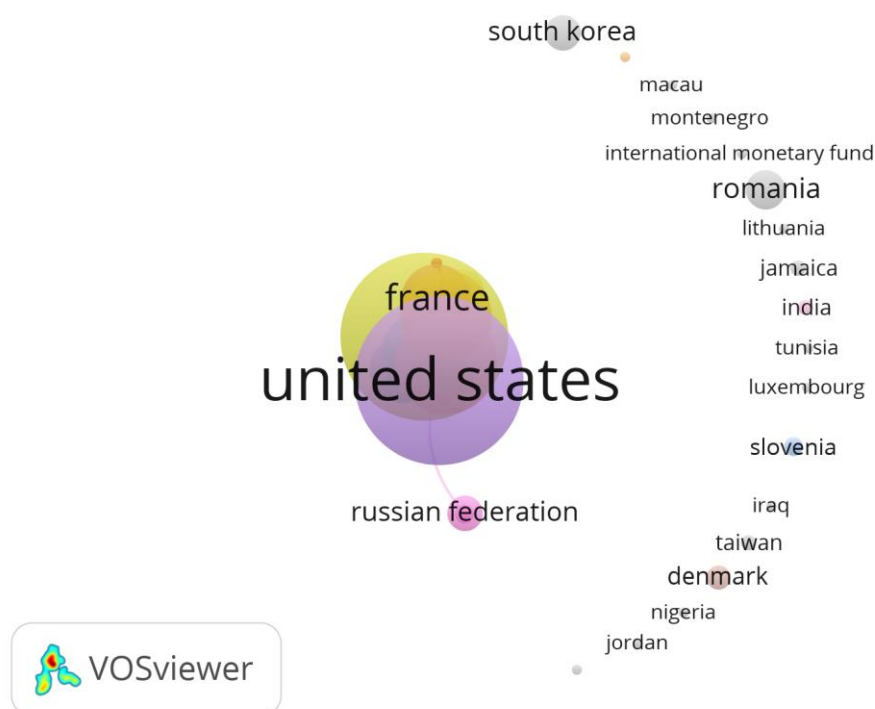


Figure 3. Co-authorship Country

Based on the figure above, the larger the circle of the publishing country, the more papers the country publishes. It can be seen that Malaysia has the brightest light. This means that the *United States* publishes the most *Early Warning Economic Crisis* themed papers compared to other countries.

Co-occurrence Analysis

Furthermore, bibliometric results will be displayed based on sub-themes, namely all keywords, author keywords, and index keywords.

1. Co-occurrence of All Key Word

VOSViewer can also find bibliometric mapping of the most used keywords in the *Early*

Warning Economic Crisis theme. The bibliometric mapping of the keywords used can be seen in the figure below. Keywords that have a larger shape indicate that the word is more widely used in journals related to *Early Warning Economic Crisis*.

This data can be used to determine the trend of keywords in recent times. Bibliometric analysis shows some keywords that are widely used in the papers that are the object of research. The more keywords that appear, the wider the indication of the most circles. While the line relationship between keywords shows how much they are related to other keywords.

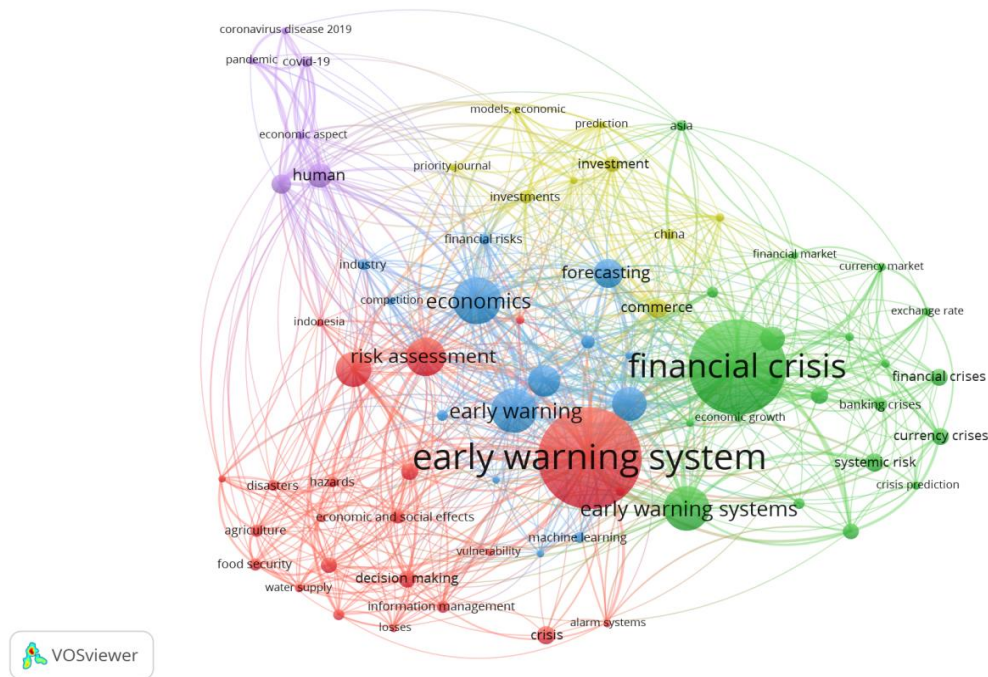


Figure 4. Co-occurrence of All Key Word

Based on the results of the analysis using VOSviewer on keywords with the theme *Early Warning Economic Crisis*, there are many clusters and are interrelated with other keywords. Keywords that have the same color indicate a very close relationship. The most widely used keyword in journals with the theme *Early Warning Economic Crisis* is *Early Warning System*.

VOSViewer can also find bibliometric mapping of keywords most used by authors in the theme of *Early Warning Economic Crisis* related to Islamic economics. The bibliometric mapping of the keywords used can be seen in the figure below. Keywords that have a larger shape indicate that the word is more widely used by authors in journals related to *Early Warning Economic Crisis*.

2. Co-occurrence Authors Key Word

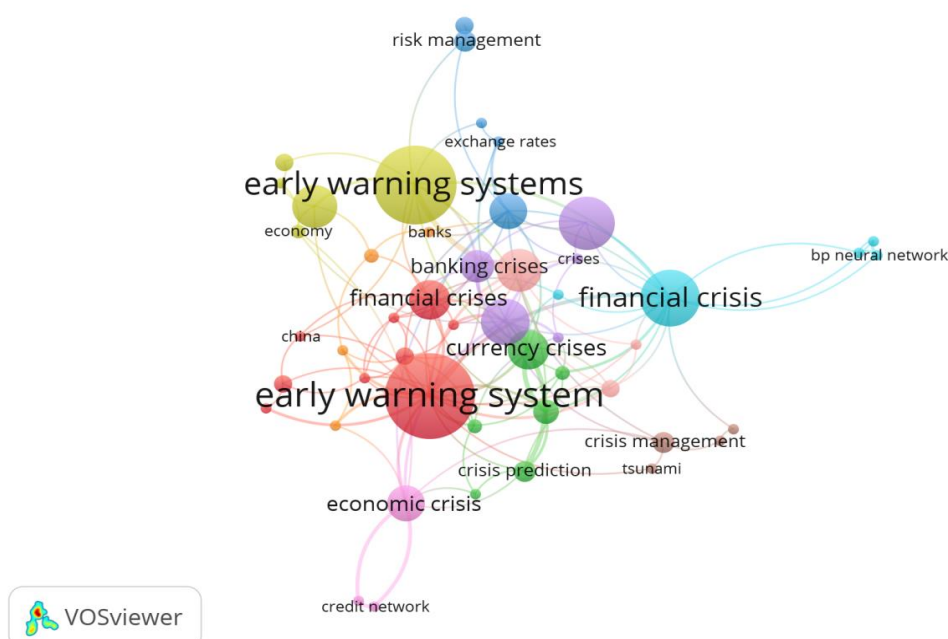


Figure 5. Co-occurrence of Authors Key Word

Based on the results of the analysis using VOSviewer on keywords that are widely used by authors in journals with the theme *Early Warning Economic Crisis*, there are many clusters and are interrelated with other keywords. Keywords that have the same color indicate a very close relationship. The keyword most widely used by authors is *Early Warning System*.

3. Co-occurrence Index

Then, this research also gets results in the form of indexes that are often used by authors and are interrelated in the theme of *Early Warning Economic Crisis* related to Islamic economics as shown in the figure below. Indexes that have the same color indicate a very close relationship.

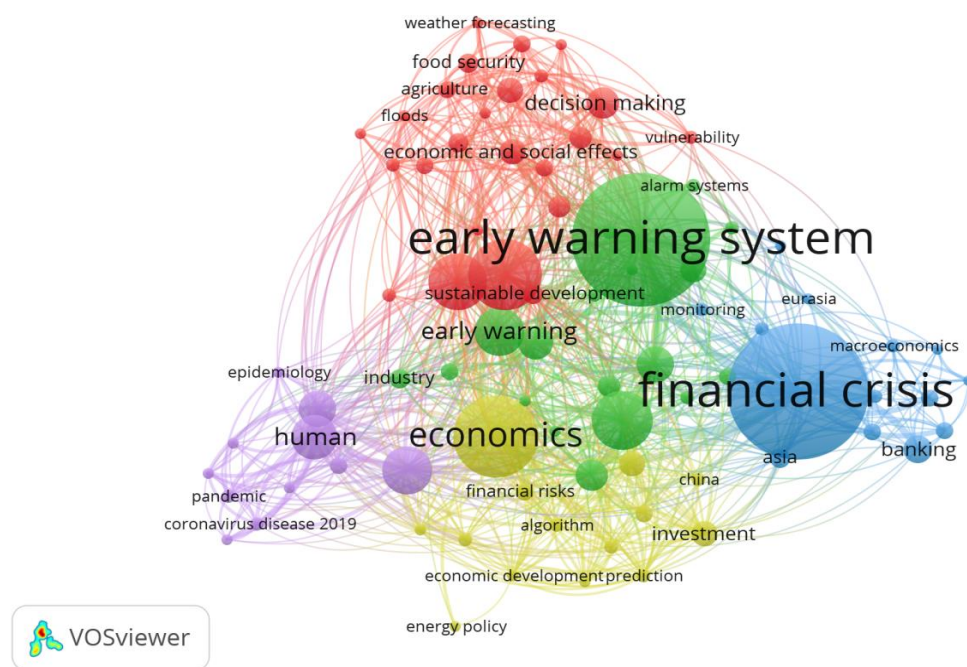


Figure 6. Co-occurrence Index

Based on the results obtained, keywords that have a larger form indicate that the more often the words in the index are used. In the word index of *Early Warning Economic Crisis* themed papers related to Islamic

economics, there are several words that are most widely used, namely *Early Warning Economic Crisis*.

Findings

Table 1. Summary

Rank	Keyword Occurrence	Authors	An institution with The Highest Publication
1.	Early Warning System	Squartini T	Center of Gedota and analysis, Faculty of Geographical Science, University of Beijing
2.	Financial Crisis	Kim T.Y	London School of Tropical Medicine, University of London, UK
3.	System	Catullo E	Bucharest University of Economic Studies, Bucharest, Romania
4.	Economic	Abdul-Majid M	International Monetary Funds, United States
5.	Finance	Wang S	Dept. of Statistics, Kaeyung University, Daegu, South Korea
6.	Forecasting	Puah C.H	Yale University, United States
7.	Risk Assessment	Rusnak M	University of Chinese Academic of Sciences, Beijing, China
8.	Risk Management	Bacci M	Kharkiv National University of Academics, Ukraine
9.	EWS Indicator	Gao J	Laboratory of Earth Surface Process and Research Ecology, Beijing
10.	Economic Crisis	Chan J.	Dept. of Business Administration, Lund University, Sweden

The results of the above research show bibliometric analysis using the VOS Viewer application from scopus indexed journal articles with the theme *Early Warning Economic Crisis*. Research related to the *Early Warning Economic Crisis* has been an interesting discussion among researchers since 1975 and continues to grow throughout the world so that researchers in the field of *Monetary System* began to produce various scientific studies in developing research related to the *Early Warning Economic Crisis*. The development of literature on *Early Warning Economic Crisis* also continues to grow until now.

Based on the results of the analysis above, it was found that research on the theme of *Early Warning Economic Crisis* has been published by various journals and many authors, resulting in a variety of topics. Then related to the most used keywords in the most popular

Early Warning Economic Crisis themed articles include 'Early Warning System, Financial Crisis, system' and others. These keywords that often appear from all the article data studied, mostly focus on the topic of *Early Warning System*, then later associated with the topic of *Crises*, then penetrate the broader theme of *Risk Assessment and Risk Management* which is the topic with the most keywords.

Most of the articles on *Early Warning System* in the topic of financial crisis were published by authors after 2010. This indicates that after the financial crisis reached its peak, scholars began to investigate and analyze how the *Early Warning System* can help in predicting various crises, namely financial crises including bank collapses (Klopota et al., 2018). They concentrated on potential indicators that lead to a collapse in the financial sector and the economy. This can be seen in the following figure:

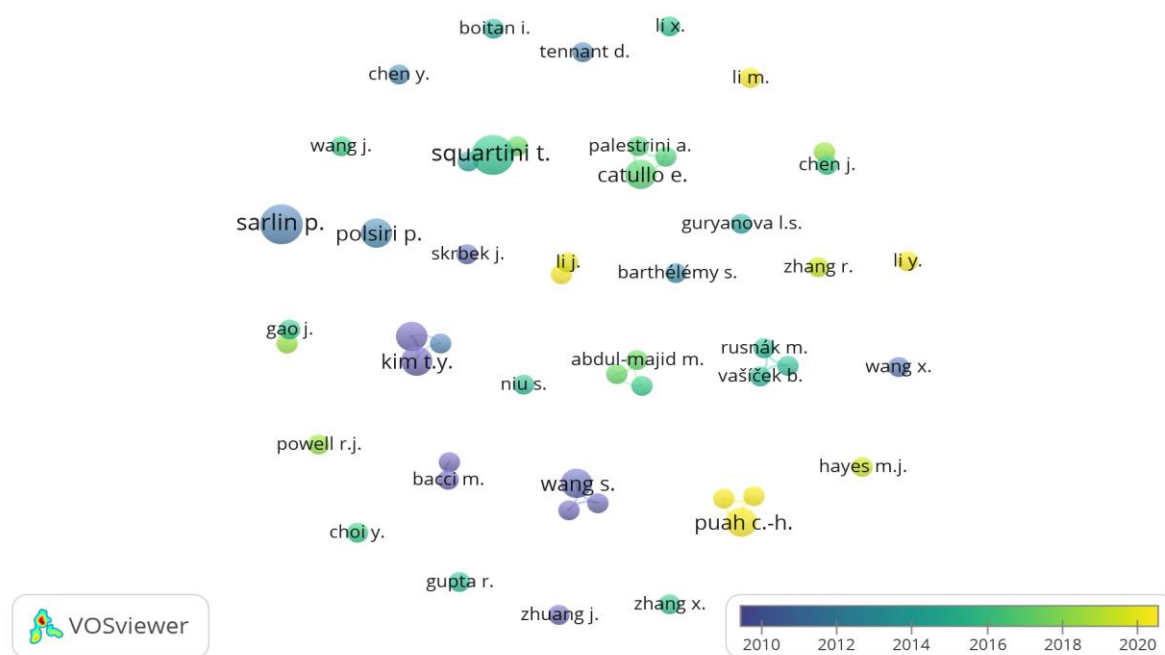


Figure 7 Author Overlay Visualization

The dynamics and fluctuations of the global economy have influenced various countries' monetary system policy setting strategies over the past four decades. (Abubakar et al., 2020). Low real interest rate policies in countries in the late 1970s, early 1990s, and early 2000s resulted in large capital inflows to developing countries, resulting in capital vulnerabilities (Claessens and Ghosh, 2013). Despite a large increase in capital flows since the *Global Financial Crisis* in 2008, foreign capital flows to developing countries in 2015 experienced *net capital outflows*. According to Warjiyo and Juhro (2016), the United States' tight monetary policy had a negative impact on a number of regions

and countries. For example, during the Volcker era, tightening monetary policy resulted in a large external debt crisis in Latin America from 1980 to 1982 and intensified the exchange rate crisis in Mexico from 1994 to 1996. (Kose, Nagle, Ohnsorge, & Sugawara, 2019). The sovereign debt crisis that triggered "the lost decade" in Latin America in 1982, the Asian financial crisis in 1998, and the European debt crisis from 2010 to 2012, are examples of regional crises.

Based on the keyword map of research themes conducted based on time, it can be seen in yellow that the topic of the crisis caused by the COVID-19 pandemic is the most discussed research.

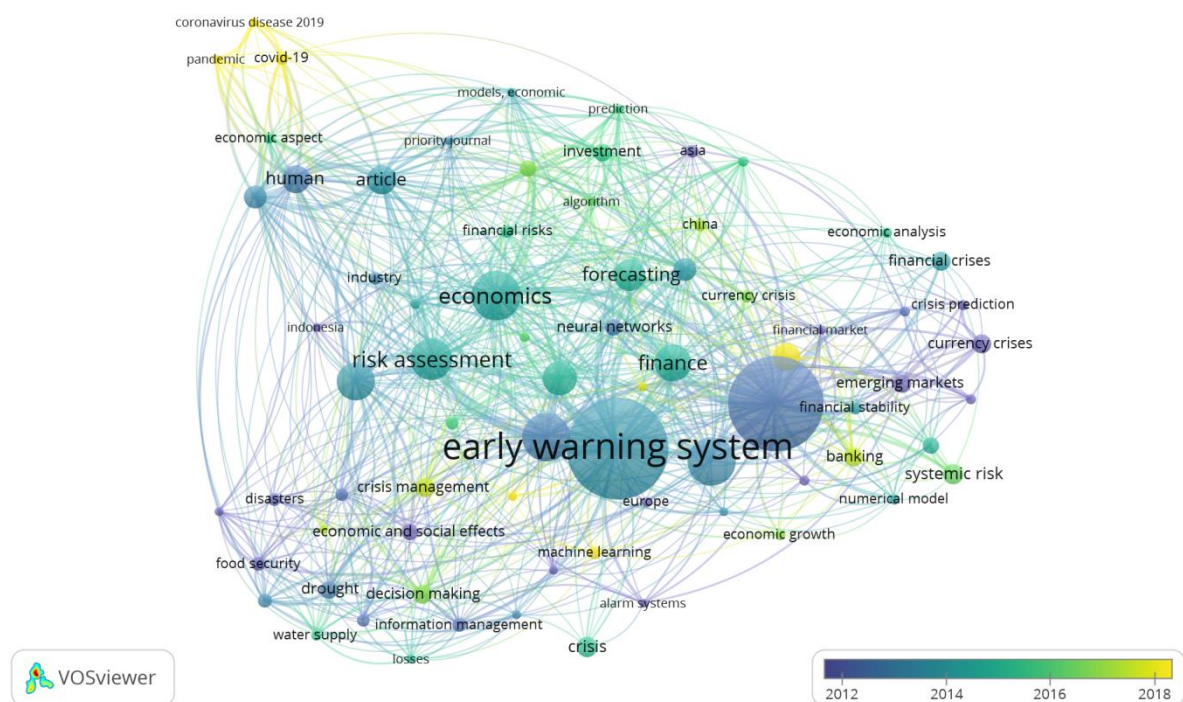


Figure 8 Keyword Overlay Visualization

Now the world is faced with the outbreak of the COVID-19 pandemic, which has triggered a severe crisis for global markets and has become a major concern for economic policy (Li et al., 2021). All economies are experiencing a crisis whose impact on economic development and financial stability is difficult to predict due to the unique nature of this crisis. For many countries, it will depend on their ability to restart economic activity while still managing the public health sector efficiently. The emergence of this crisis has an impact on the financial sector activities in countries (Elnahass et al., 2021).

The increasing frequency of pandemics due to new variants is now causing great concern. Therefore, *early warning system* strategies are in place to minimize human and financial losses as a result of pandemics around the world. As the COVID-19 pandemic winds down, we must consider how we handled the recent global disasters and how we can better prepare for the next global crises, given the fluctuating economic conditions

CONCLUSION

This study was conducted to determine the development map of research on the theme of Early warning system during the period 1990-2021 from 371 published journal sources. The results show that there have been quite a lot of papers published on this

theme. Visualization of bibliometric mapping found that the author who conducted the most research was Squartini T. The organization that published the most papers on the theme of Digital Banking was the Center for Geodata and Analysis. While the country that published the most papers on the theme of Early Warning Economic Crisis is the United States.

Early warning systems help organizations reduce losses and are critical in detecting emergencies from occurring. This study provides insights into bibliometric trends of research in the domain of Early warning systems in the fields of management, economics, public administration, and business to conduct a comprehensive literature assessment on Early warning systems. Our study contributes to the field of early warning system development and applications in the economic and financial sectors by providing new knowledge and critical insights into a previously unexplored topic. Early warning systems have evolved into a reduction technology that enables more efficient actions and lower costs. As a result, gathering knowledge to detect risks before it is too late is essential for companies to maintain a competitive advantage in the market.

Our research also contributes to a better understanding of the use of early warning systems in business, finance and economics. This research exposes several different approaches to using Early warning

systems. The findings are useful for managers at all levels of the organization, as it is crucial to identify the additional value of early warning systems from a risk reduction perspective. Companies can learn about developments in the field of early management systems and information that can help their decision-making process as a consequence of our research findings.

Furthermore, for academics and future researchers, bibliometric studies on Early warning systems should be studied using other databases that are more updated. Further studies on this topic should focus on deeper investigations, which may include Early warning system case studies using qualitative data approaches as well as other more robust quantitative data.

REFERENCES

- Abubakar, A., Diah Utari, G. A., & Azwar, P. (2020). Early warning indicators and optimal policies for mitigating economic crises: Evidence from meta-analysis. *Bulletin of Monetary Economics and Banking*, 23(2), 269-293. <https://doi.org/10.21098/bemp.v23i1.1421>
- Barrell, R., Davis, E.P., Karim, D., Liadze, I., 2010. Bank regulation, property prices and early warning systems for banking crises in OECD countries. *J. Bank. Financ.* 34, 2255-2264
- Bussiere, M., & Fratzscher, M. (2006). Towards a new early warning system of financial crises. *Journal of International Money and Finance*, 25(6), 953-973. <https://doi.org/10.1016/j.jimonfin.2006.07.007>.
- Casu, B., Clare, A., Saleh, N., 2012. Towards a New Model for Early Warning Signals for Systemic Financial Fragility and Near Crises: An Application to OECD Countries, MPRA Working Paper No. 37043. University Library of Munich, Germany
- Demirguc-Kunt, A., Detragiache, E., March 1998. The determinants of banking crises in developing and developed countries. *IMF Staff Papers* 45 (1).
- Edison, H. J. (2003). Do indicators of financial crises work? An evaluation of an early warning system. *International Journal of Finance and Economics*, 8(1), 11-53. <https://doi.org/10.1002/ijfe.197>
- Fearnley, C. J., & Dixon, D. (2020). Editorial: Early warning systems for pandemics: Lessons learned from natural hazards. *International Journal of Disaster Risk Reduction*, 49(May), 101674. <https://doi.org/10.1016/j.ijdrr.2020.101674>
- Hawtrey, R.G. *Monetary Reconstruction*; Longmans: London, UK, 1926.
- Himmler, S., van Exel, J., & Brouwer, W. (2021). Did the COVID-19 pandemic change the willingness to pay for an early warning system for infectious diseases in Europe? *European Journal of Health Economics*, 0123456789. <https://doi.org/10.1007/s10198-021-01353-6>.
- Kaminsky, G. L., Lizondo, S., & Reinhart, C. (1999). Leading indicators of currency crises. *International Monetary Fund Staff Papers*, 45, 1-48.
- Klopotan, I., Zoroja, J., & Meško, M. (2018). Early warning systems in business, finance, and economics: Bibliometric and topic analysis. *International Journal of Engineering Business Management*, 10, 1-12. <https://doi.org/10.1177/1847979018797013>
- Lang, Y.; Yang, Q. Does public infrastructure breed consumption downgrade and overcapacity in China? A DSGE approach on macroeconomic effects. *Sustainability* 2019, 11, 831
- Royani, Y., & Idhani, D. (2019). Bibliometric Analysis of Marine Research Journal in Indonesia. *Librarian Media*, 25(4), 60-65.
- Savona, R., Vezzoli, M., 2015. Fitting and forecasting sovereign defaults using multiple risk signals. *Oxf. Bull. Econ. Stat.* 77 (1), 66-92
- Semin, A., Vasiljeva, M., Sokolov, A., Kuznetsov, N., Maramygin, M., Volkova, M., Zekiy, A., Elyakova, I., & Nikitina, N. (2020). Improving early warning system indicators for crisis manifestations in the Russian economy. *Journal of Open Innovation: Technology, Markets, and Complexity*, 6(4), 1-21. <https://doi.org/10.3390/joitmc6040171>.
- Subana, M. (2005). and Sudrajat. *Basics of Scientific Research*, 25.
- Sugiyono. 2008. *Business Research Methods*. Alfabeta: Bandung.
- Van Eck, N. J., & Waltman, L. (1996). VOS: A new method for visualizing similarities between objects. In *Advances in data analysis* (pp. 299-306). Springer, Berlin, Heidelberg.
- Wijaya, T. (2013). *Economic and business research methodology theory and practice*. Yogyakarta: Graha Ilmu.
- Wong, J., Wong, T.C., Leung, P., 2010. Predicting banking distress in the EMEAP economies. *J. Financ. Stab.* 6, 169-179.