Designing a Financial Stress Index Based on Global Volatility and Its Relationship with the VIX Index

Hamidreza Reisizadeh
Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
Hamidreza.reisizadeh@yahoo.com

Mirfeiz Fallah Shams
Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran,
(Corresponding Author)
fallahshams@gmail.com

Gholamreza Zomoredian
Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
gh.zomorodian@gmail.com

Submit: 03/09/2023 Accept: 24/10/2023

ABSTRACT

Financial stress can be considered a disruption in the normal functioning of financial markets and its indicators are essential tools for assessing the stability and vulnerability of financial systems. This research focuses on designing and explaining a comprehensive financial stress index that incorporates external financial indicators and provides a comprehensive outlook on systemic risks facing an economy in the time span from October 31, 2012, to October 21, 2022. In this research, five important global indicators—Brent crude oil price, gold price per ounce, the U.S. Dollar index, the NASDAQ Composite index, and the Euro to Dollar exchange rate—have been used to construct the financial stress index. Various methods such as principal component analysis and statistical regression models are employed to determine optimal weights. Sensitivity analysis is performed to ensure the stability and reliability of the index under various weighting scenarios. Therefore, for the final analysis in this research, open-source software R 4.2.1 and Eviews1 have been utilized. This research indicates a significant relationship between the VIX fear index and the designed financial stress index. Additionally, the outcome of weighting the research variables using a hierarchical technique reveals that the gold price carries the highest weight of 0.369, followed by the U.S. Dollar index with 0.222 in the third place, the Euro to Dollar exchange rate with 0.174, and Brent crude oil index with 0.170, while the NASDAQ Composite index holds the fifth position with a weight of 0.065.

Keywords: Financial stress index (FSI), economic indicators, VIX index, financial markets.

1. Introduction

Financial markets are inherently vulnerable to various forms of stress and instability that can have wide-ranging consequences for economies and societies as a whole (Rawhouser, Vismara& Kshetri, 2023). Identifying and quantifying financial stress has become a primary concern for policymakers, investors, and researchers (Iqbal, Naeem & Suleman, 2022).

Financial stress arises from turbulence and vulnerabilities in financial structures. Therefore, the greater the financial fragility (weakness in financial conditions and structures), the more it not only increases financial stress itself but also amplifies and strengthens it through increased financial losses, risk (increase in expected potential losses), and market uncertainty. This, in turn, leads to an upward trend in financial stress, raising the cost of credit and creating uncertainty among financial institutions and investors, ultimately causing a downward trend in the economy (Rahimi Baghi, Arab Salehi, & Vaezzadeh, 2019: 124). Increased financial stress results in heightened uncertainty about the value of financial assets, which can lead to increased price fluctuations in these assets. Price fluctuations, while making businesses more cautious, also delay critical decisions regarding investments or hiring until uncertainty is resolved. Furthermore, financial stress prompts banks to adopt stricter credit standards, reducing economic activity. One of the reasons investors seek higher returns on bonds or stocks (during financial crises) is because banks are less willing to lend (Kordlooyi & Asiayi Taheri, 2016: 4).

Therefore, a Financial Stress Index (FSI) has been developed as a tool for measuring and quantifying the vulnerability of a financial system by analyzing a set of indicators. This valuable insight provides information about current risks and potential threats to economic stability (Ishrakieh, Dagher & El Hariri, 2020). Brent crude oil prices play a significant role in economic stability, especially for oil-dependent countries like Iran (Yildirim & Arifli, 2021). Price fluctuations in crude oil can affect government revenue, trade balances, and currency valuations, ultimately impacting overall financial stress levels (Aliyu, 2009). Gold, often considered a safe asset, acts as a reliable indicator of market sentiment and overall risk appetite (Grable & Lytton, 2021). The price per ounce of gold reflects investor perceptions of uncertainty and serves as a fundamental component of financial stress (Beckmann, Berger & Czudaj, 2019). By analyzing the price of gold, the financial stress index can capture changes in market confidence and the overall risk environment (He, Mishra, Aman, et al., 2021).

The VIX index, which is an abbreviation of the term Volatility Index, is a real-time indicator that focuses on predicting market fluctuations. Among stock market investors in the United States, this index is used as a crucial gauge. Essentially, it reflects traders' expectations of the S&P 500 index in the not-so-distant future, based on trades executed on options for buying and selling the S&P 500 index for a 30-day period on the Chicago Board Options Exchange (CBOE). This index is used both as a measure of the existing market risk and to gauge the sentiments of stockholders. The VIX index is also commonly referred to as the "fear index." Many stockholders, analysts, and portfolio managers use this index as a tool to assess market risk, fears, and the overall sentiments prevailing in the market before making investment decisions.

Furthermore, this research utilizes the best international practices and models of financial stress indices present in developed and emerging markets outside of Iran. By comparing Iran's financial stress index with those of other countries, insights can be gained into the unique characteristics and challenges facing Iran's financial markets. This comparative analysis illuminates the similarities and differences in the drivers of financial stress and aids in identifying potential vulnerabilities that may require targeted policy interventions.

Review of Literature

A summary of research related to the study's topic is presented in Table 1:

Table 1: review of literature

Year	Authors	Research topic	Research summary
2023	Ghafari Golafshani , Fallah, Safa, et al.	Designing a Financial Stress Index and Testing It under Uncertainty Conditions (Case Study: Financial Market and Stock Exchange in Iran)	The results show that all independent research projects have a positive and significant effect on the important financial index, except for the coin price volatility index, which has a negative and significant effect. The coefficient of determination of the model is also 0.8736, which indicates that the quality of the fitted model is favorable.
2020	Rezazadeh & Fallah	Investigating the spillover of financial stress index fluctuations on inflation, interest rate, liquidity and industry index with emphasis on GARCH-BEKK, VAR and Granger causality models	Their results indicate that there is a causality relationship between the financial stress index, inflation, interest rates, and liquidity. However, in examining the causality relationship between the financial stress index and the industry index, the test results indicate that it is the industry index that causes changes in the financial stress index in the long term, but the financial stress index does not have an impact on the industry index.
2019	Heydarian et al.	Investigating the calculation of the financial stress index and analyzing its effects on economic growth using the Markov-switching autoregression model	The results of the model estimation showed that Iran's economy experienced negative financial stress over a 13-year period from 1991 to 2017 and positive financial stress over a nine-year period, respectively leading to a decrease and an increase in economic growth in the country. However, the stability during recession years and negative financial stress was greater than during boom years and positive financial stress, to the extent that the overall effect of financial stress on economic growth was negative and significant. It can be argued that one of the reasons for the occurrence of financial stress and subsequent financial crises is the market-driven nature of the country's financial structure.
2023	Hong, Li, Wang, et al.	New evidence of significant risk transfer between financial stress and international crude oil markets.	The results obtained from the time domain test indicate that their causality is generally from severe shocks to mild shocks, which has not been previously found. To further detect the long-term and short-term effects of these shocks, we use the frequency domain test and find that these causes are primarily found for the long term.
2022	Nura & Korkmazb Korkmazb	Volatility spillover between Bitcoin and financial stress index	The empirical findings from the analysis of impulse response support the transmission of risk between BTC and FSI series. Results and findings: Changes in the return series of BTC and the FSI series are primarily generated by themselves, and the series mostly capture the impact of their own shocks. By comparing the decomposition of the variance of the volatility series with the analysis results, it can be said that changes in the volatility series are primarily caused by each other.
2022	Mezghani & Abbes	Forecast the Role of GCC Financial Stress on Oil Market and GCC Financial Markets Using Convolutional Neural Networks	Their results indicate that financial stress indices contribute to improving predictive performance. This suggests that the 1D-CNN model exhibits better predictive performance on out-of-sample data. Given the impact of financial stress on risk coverage between Brent and financial markets, the results on the role of oil in market risk coverage for stress markets are another interesting finding. Out-of-sample estimates for equity and bond markets show higher variability in risk coverage with oil for negative (positive) financial stress.
2022	Dos, Maira, Dota, et al.	Investigating financial stress and crude oil-induced volatility: new evidence from the continuous wavelet transform framework	Their findings indicate the presence of co-movements between oil fluctuations and financial stress, primarily around economic turmoil phases. The patterns and strength of such co-movements vary over time. The direction of the relationship is predominantly positive, and the lead-lag relationship suggests that OVX tends to lead the relationship. Furthermore, it is observed that the causality between the variables is mostly two-way, but the causality from OVX to FSI is relatively stronger. Additionally, the relationship between OVX and stress is assessed under two different economic states, namely turmoil and tranquility. The results suggest that the causal co-movement intensifies mainly during turmoil states. Overall, the findings of this study can be valuable for policymakers and investors in predicting imminent changes in the relationship to mitigate potential adverse effects.

Year	Authors	Research topic	Research summary
2022	Fo, Chen, Sharif, et al.	The Role of Financial Stress, Oil, Gold, and Natural Gas Prices on Clean Energy Reserves: Global Evidence from a Quantile Approach	The empirical findings of their study show that an increase in the financial stress index and the price of oil and gold significantly reduces the performance of clean energy stocks in the long and short term, while natural gas has a positive effect on clean energy reserves only in the long term. While in the short term, this study significantly provides a clear picture of the interdependence of these macroeconomic variables in all market conditions based on experimental results.
2022	Rezazadeh & Mohseninia	The effect of financial stress on gold, currency and stock markets in Iran: a time-varying Granger-causality approach	The results of estimating variance heterogeneity and testing for Granger causality using time series variables do not provide any evidence of causality between financial stress and the stock market index when using forward and backward algorithms. The findings suggest that financial stress originates from changes in the Iranian gold market and has no impact on the foreign exchange and equity markets.
2020	Ishrakieh et al.	A financial stress index for a highly dollarized developing country	A real-time continuous measurement is made that quantifies the level of systemic stress by measuring latent conditions. As a measure of financial conditions, IFEFSI should provide valuable information to macro-prudential regulators who aim to maintain a smooth and resilient financial system. By using it as a tool to help monitor, identify and address any potential crisis, they can better maintain financial and economic stability in Lebanon.
2020	Shahzad, Farid, Wang & Maranshah	They investigated the importance of the terms specific risk, market risk, and total risk in different stages of the company's life cycle.	The findings have shown that all three types of risk are significantly higher in the stages of introduction, growth, and decline, because competitive advantages, resource base, and capabilities are limited. The results have shown that the risks are lower during the growth stage.

Methodology

In terms of purpose, the current research is applied and based on how to obtain the required data, it is a descriptive research. Among the different categories of descriptive research (survey research, correlational research, action research, case study, post-event research, exploratory research), it can be classified as a survey-correlation type according to the characteristics of the current research. and included regression.

The purpose of this research is to design a financial stress index in response to some external financial indicators. which is answered through the following question and hypothesis.

- Is the VIX fear index effective on the designed financial stress index?

As a result, the research hypothesis is as follows:

Hypothesis: There is a significant relationship between the VIX fear index and the financial stress index designed in this research.

In this research, the statistical population is the data of foreign financial indicators. Our sampling method according to the nature of the data, i.e. the time series of the total index and sub-indices, is cross-sectional. The statistical sample includes foreign financial indicators. All the variables used in this research are on a quantitative scale and observations in the form of daily time series from 10-31-2012 to 10-21-2022, which have been used for modeling purposes after cleaning and historical equalization.

Gathering information using new Rahvard 3 software, information stored in the library of the Tehran Stock Exchange Organization and the Internet sites of the Stock Exchange Organization, the comprehensive information system of publishers and the Financial Information Center of Iran and the Federal Reserve website and Yahoo Finance has been implemented.

Excel spreadsheet software was used to prepare the necessary variables to be used in the hypothesis test model. First, the information collected in the work pages created in the environment of this software was entered and then the necessary calculations were made to obtain the variables of this research. After calculating all the necessary variables to be used in the models of this research, these variables were combined in single worksheets to be transferred to the software used in the final analysis. In this research, the open source software R 4.2.1 and Eviews13 were used to perform the final analysis.

Research steps

Step 1: collecting data, checking and designing the most appropriate model to estimate the expected return of each of the indicators and checking the effect of Arch in each of the models.
Step 2: estimation of conditional volatility and dynamic correlation between indicators through GAHCH and DCC models.
Step 3: Determining the weight and importance coefficient of each index through the hierarchical analysis method.
Step 4: designing (build) financial stress index.
Step 5: evaluation of the financial stress model in the foreign capital market.

Index	The symbol used in the research
Stress index	FSI
Brent crude oil price	Oil
Price per ounce of gold	Gold
US dollar index	Dxy
NASDAQ Stock Exchange	Nasdaq
The exchange rate of the Euro to the Dollar	EURUSD

The process of constructing a financial stress index.
The primary formula for constructing a stress index.
In this research, a financial stress index based on the methodology of Hullo (2012) has been designed based on the fluctuation of some important global financial market indices, and its formula is as follows:
Relation 1

$$FSI_t = (w.s_t)\, C_t\, (w.s_t)'$$

Where W represents the weights of the sub-indices, S is the vector of sub-indices, and (W^0S_t) is the product of the weight elements with the sub-index vector at time t. (W^0S_t)´ is the inverse of this matrix.
Ct is the matrix of cross-correlation coefficients between sub-index j and i at a given time (Rezazadeh & Fallah Shams, 2020).
Relation 2

$$C_t = \begin{bmatrix} 1 & \rho_{12.t} & \rho_{13.t} \\ \rho_{21.t} & 1 & \rho_{23.t} \\ \rho_{31.t} & \rho_{32.t} & 1 \end{bmatrix}$$

When all sub-indices are fully correlated, the IFSI index should be equal to the square root of the weighted average of three sub-indices (i.e., $v_t = w \circ s_t$), in other words, it reflects a situation where all sub-indices are historically at their minimum (minimum financial stress) or simultaneously at their maximum (maximum financial stress). However, in most cases, correlation is not completely homogeneous and less than perfect. To calculate the composite financial stress index, the cross-correlation matrix of variables over time, Ct, needs to be estimated.

Calculation of Sub-Indexes

In this section, the conditional standard deviations of the multivariate GARCH model (conditional correlation approach) have been used as sub-indexes in the formula for constructing the stress index. After preparing the data and removing outliers, a multivariate GARCH model (dynamic conditional correlation approach) was estimated. Following the estimation of this model, the necessary components such as conditional standard deviations as daily volatility and conditional correlation matrices are extracted.

For data preparation, the identification and adjustment of outliers was carried out using the method proposed by *Boudt* et al. (2008). Based on this method, the Mahalanobis distance function is first calculated for each observation and sorted. Distances greater than some threshold (1-α) percent are identified as outliers, and finally, the outlier observations are adjusted.

Before modeling, the presence of dynamic correlation is examined using the test designed by Engle and Sheppard (2001). The obtained p-value is less than 0.01, indicating the rejection of the null hypothesis of constant correlation at the 99 percent confidence level. Therefore, the alternative hypothesis, which implies the dynamism of correlation and somewhat supports the DCC-GARCH approach, is accepted.

The Dynamic Conditional Correlation (DCC) model is, in fact, a generalized form of the constant conditional correlation model developed by Engle (2002). In a nutshell, a univariate GARCH(1) model is used as a single-variable GARCH model in measuring conditional variance matrices of returns for use in the DCC model.

This model is as follows:

Model 1

$r_t = \mu_t + a_t$

$a_t = H_t^{1/2} z_t$

$H_t = D_t R_t D_t$

$R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2}$

$\varepsilon_t = D_t^{-1} a_t \sim N(0; R_t)$

$$\bar{Q} = \frac{1}{T}\sum_{t=1}^{T} \varepsilon_t \varepsilon_t^T$$

$Q_t = (1 - a - b)\bar{Q} + a\varepsilon_{t-1}\varepsilon_{t-1}^T + bQ_{t-1}$

where r_t is an n-dimensional vector of time series at time t (typically considered as the logarithmic returns of an index).

μ_t: An n-dimensional vector of mean equations at time t.

a_t: An n-dimensional vector of disturbances at time t.

H_t: An n×n matrix of conditional variance-covariance of a_t at time t.

$H_t^{1/2}$: An n×n matrix, usually obtained through the Cholesky decomposition of the H_t matrix.

D_t: An n×n diagonal matrix derived from the conditional standard deviations of a_t at time t.

R_t: An n×n matrix of conditional correlations of a_t at time t.

z_t: An n-dimensional vector of standard normal random variables.

$\bar{Q}$: A non-conditional covariance matrix of ε_t

ε_t: Standardized residuals that are correlated.

$a; b$: Parameters of the DCC model that must satisfy the following conditions.

Relation 1) $a \geq 0$; $b \geq 0$

2) $a + b < 1$

The idea of creating a volatility index based on options prices emerged shortly after the introduction of tradable options on the stock exchange in 1973. Gastineau (1977) proposed a volatility index that reflects the average volatility resulting from 14 equity options, while Cox and Rubinstein (1985) improved this method by using multiple strike options on each stock and weighting the volatilities in such a way that the index has a fixed time to expiration.

Volatility indices like the Chicago Board Options Exchange (CBOE) options on the board of directors represent the culmination of these previous efforts and expand on this concept in two important ways. First, VIX depends on options on the index rather than individual stocks. Second, it relies on implied volatilities of both call and put options. This not only increases the information content collected by the index but also reduces potential biases due to aging at the index level and inaccurate measurement of the risk-free rate.

In summary, the VIX index measures market expectations of short-term volatility derived from the prices of stock options in the equity market. It has three main differences from the VXO index. First, VIX relies on options on the S&P 500 index with a wide range of strike prices, rather than focusing on monetary at-the-money options like VXO. Second, VIX does not use the Black-Scholes-Merton option pricing framework and employs a model-free estimator of implied volatilities (Britten-Jones and Neuberger, 2000; Jiang and Tian, 2005). Third, VIX calculates options on the S&P 500 index rather than the S&P 100 index, which seems more natural for the S&P 500, the primary benchmark for the mutual fund industry and derivative markets. The model-free estimator of implied volatilities used by the Chicago Board Options Exchange (CBOE) for calculating the VIX index.

Relation 4:

$$\sigma^{۲} = \frac{۲}{T}\sum_i \frac{\Delta K_i}{K_i^{۲}} e^{RT} Q(K_i) - \frac{۱}{T}\left[\frac{F}{K_{.}} - ۱\right]^{۲}$$

$$VIX = \sigma \times ۱۰۰$$

- T: Time to maturity
- F: The futures value based on the exercise prices of the options on the index
- K: The first exercise price less than F
- Ki: The exercise price of the i^{th} out-of-the-money option: Call option if Ki > K0; Put option if Ki < K0; Both call and put options if Ki = K0.
- ΔKi: The spacing between exercise prices based on the formula
- R: The risk-free interest rate to the time of maturity
- Q(Ki): The average of the absolute differences between the bid and ask orders for options with exercise price Ki

VIX is calculated using put and call options with the nearest two-month expiration to cover a 30-day calendar period. Eight days before expiration, VIX rolls into the second and third months of the contract to reduce any pricing anomalies that may occur due to proximity to expiration. For precision, CBOE fixes the risk-free rate at %r = 1.162% and measures the expiration time T in minutes instead of days: T = TSC = TY, where TSD is the total number of remaining minutes until expiration. At 8:30 on the settlement day, TY refers to the number of minutes in a year.

Regarding the level of the forward index, CBOE assumes $F = K_* + e^{rT_*}\ (C_* - P_*),$, where *C and *P are the "at-the-money" call and put option prices with maturity *T and exercise price *K that minimize the spread between bid and ask prices. Finally, it determines a strike price K0 as the immediate operational price below the forward index F. Then, the algorithm sorts all options in ascending order based on their bid prices, selecting only call/put options with non-zero bid prices and strike prices above K0 to prevent double-counting. To avoid double-counting, the average of the mid-prices of call and put options is placed at K0. CBOE performs these calculations for both short-term and long-term options, resulting in a forward index level and a strike threshold for each term. This ultimately means that the algorithm provides estimates of implied volatilities in (1) for short-term and long-term options, and the VIX index is derived singularly from the linear interpolation of these two estimates with a fixed 30-day time to expiration. For an in-depth discussion of approximate errors in the VIX index, see Andersen and Bondarenko (2007).

In the following, regression analysis, the Fisher F-test, the coefficient of determination, the Shapiro-Wilk normality test, the stationarity test (Dickey-Fuller unit root test), the heteroscedasticity test (ARCH effects), and the structural vector autoregression (SVAR) model are used.

Based on the obtained Granger causality results, the order of variables is as follows: first, the VIX index is considered, followed by the stress index explained in the model. The matrix of constraints is defined as follows, where the first row and column are related to the VIX index, and the second row and column are related to the described stress index.

$$A = \begin{pmatrix} 1 & 0 \\ C(1) & 1 \end{pmatrix}, \quad B = \begin{pmatrix} C(2) & 0 \\ 0 & C(3) \end{pmatrix}$$

The element a_{21}, denoted by the parameter C(1), signifies the concurrent impact or influence of the VIX index on the described stress index in the research. Given the identification of matrices A and B, the relationship between structural shocks and reduced-form shocks is as follows: $Au_t = B\varepsilon_t$.

$$\begin{pmatrix} 1 & 0 \\ C(1) & 1 \end{pmatrix} \begin{pmatrix} u_t^{VIX} \\ u_t^{FSI} \end{pmatrix} = \begin{pmatrix} C(2) & 0 \\ 0 & C(3) \end{pmatrix} \begin{pmatrix} \varepsilon_t^{VIX} \\ \varepsilon_t^{FSI} \end{pmatrix}$$

Therefore, in order to extract the matrix of the residuals of the structural VAR model and apply the constraints, we rewrite the relationship in the following form:

$$\left[\begin{pmatrix} 1 & 0 \\ C(1) & 1 \end{pmatrix} \begin{pmatrix} u_t^{VIX} \\ u_t^{FSI} \end{pmatrix}\right]^T \begin{pmatrix} C(2) & 0 \\ 0 & C(3) \end{pmatrix}^{-1} = \begin{pmatrix} \varepsilon_t^{VIX} \\ \varepsilon_t^{FSI} \end{pmatrix}$$

Calculation of optimal weights for financial stress index variables using the Analytic Hierarchy Process (AHP) approach

We used the Analytic Hierarchy Process (AHP) approach to calculate optimal weights for the financial stress index variables in this research, based on expert opinions.

The hierarchical decision-making method is one of the most widely used tools for multi-criteria decision-making, and its diversity has been extensive in various fields. The problem is how to choose one option among several available options or prioritize them based on their importance. In this problem, each option is assigned a score based on the comparisons made with each other and considering the importance scores of the criteria. This score indicates the option's better suitability based on the defined criteria. However, assigning scores directly is not a straightforward task and may lead to biases in the final results. Therefore, we need an intelligent solution for scoring. In this regard, in the 1970s, the Analytic Hierarchy Process (AHP) method was designed by Thomas Saaty to solve such problems.

The foundation of the AHP process is pairwise comparisons. This method allows us to quantify and evaluate qualitative issues for which there is no measurement unit. In the AHP process, elements at each level are compared pairwise with their respective elements at the higher level, and their weights are calculated. These weights are called relative weights, and by combining these weights, the final weight of each option is determined.

After selecting 15 experts in the financial field and conducting oral surveys, we delve into the Analytic Hierarchy Process and extract the relevant weights.

Analysis of Research Findings

value of 0.0031, indicating that this index has lower risk compared to the others. Furthermore, the highest standard deviation is related to the Brent Crude Oil index with a value of 0.03, indicating higher volatility and risk compared to other indices. The obtained skewness for all variables (with some exceptions for Brent Crude Oil) falls within the range of (-2, 2), so the distribution of these three variables can be considered relatively symmetric. On the other hand, given the positive and greater than 3 values of kurtosis, we find that the distribution peak is sharper and more leptokurtic than the normal distribution.

Based on the obtained results, it appears that the t-Student statistical distribution is more suitable for these three variables than the normal distribution.

To test the stationarity assumption of the returns of currencies, an augmented Dickey-Fuller unit root test has been used. Considering the test statistics values for the returns of Brent Crude Oil, Gold, Dollar Index, NEX Index, and the Euro/Dollar exchange rate, which are -11.10, -13.47, -13.22, -13.42, -14.29, and each with a significant value less than 0.01, the stationarity assumption for the returns of all five studied indices is accepted.

By examining concentration measures (mean and median), we find that the average daily return of the NEX index with values of 0.05% and 0.12% is higher compared to the returns of other research indices. On the other hand, looking at the standard deviation values of the returns for these indices, we observe that the lowest value belongs to the Dollar index with a

The positivity of parameter a suggests that following a shock in the return series of the indices, an increase in conditional correlation for the next period can be expected. Parameter b in the DCC model also represents the effect of the conditional correlation in the previous period on the conditional correlation in the current period. The larger and closer to 1 this parameter is, the expectation is that for each pair of calculated conditional correlations, the conditional correlations in the current period will be close to the conditional correlations in the previous period.

Table 1. Descriptive statistics related to the daily returns of the research variables

Descriptive statistics	Brent Crude Oil	Gold (in troy ounces)	Dollar Index	NASDAQ Stock Exchange	Euro to Dollar Exchange Rate
Number of observations	2449	2449	2449	2449	2449
Minimum	-0.6437	-0.0981-	-0.0209	-0.1315	-0.0267
Maximum	0.412	0.058	0.0188	0.0894	0.0306
first quarter	-0.0106	-0.0047	-0.0017	-0.0044	-0.0027
third quarter	0.0115	0.0052	0.0018	0.007	0.0027
Average	-0.0001	0.00	0.0001	0.0005	-0.0001
Mean	0.0006	0.0002	0.00	0.0012	-0.0001
standard deviation	0.031	0.01	0.0031	0.013	0.005
Skewness	-2.8953	-0.5509	0.2333	-0.8222	-0.0215
Elongation	99.8162	7.2055	3.673	9.4577	2.1843

Table 2. Results of preliminary tests before modeling to investigate the fundamental assumptions

No.	Index	Shapiro-Wilk Test		Augmented Dickey-Fuller test		ARCH effect model	
		Statistics	Sig. level	Statistics	Sig. level	Statistics	Sig. level
1	Brent Crude Oil	0.70	<0.01	-11.10	<0.01	474.38	<0.01
2	Gold (in troy ounces)	0.94	<0.01	-13.47	<0.01	89.64	<0.01
3	Dollar Index	0.97	<0.01	-13.22	<0.01	167.07	<0.01
4	NASDAQ Stock Exchange	0.91	<0.01	-13.42	<0.01	803.31	<0.01
5	Euro to Dollar Exchange Rate	0.98	<0.01	-14.29	<0.01	153.80	<0.01

Table 3. estimated coefficients of dynamic conditional correlation

Parameter		Estimated coefficient	SD	T statistics	Sig. level
Brent Crude Oil	[Oil].mu	0.000333467	0.000324	1.03	0.30
	[Oil].omega	3.29082E-06	2.53E-06	1.30	0.19
	[Oil].alpha1	0.089657559	0.015444	5.81	0.00
	[Oil].beta1	0.909342277	0.015402	59.04	0.00
	[Oil].shape	6.468432181	0.829704	7.80	0.00
Gold (in troy ounces)	[Gold].mu	9.50444E-05	0.00015	0.63	0.53
	[Gold].omega	5.63819E-07	2.33E-06	0.24	0.81
	[Gold].alpha1	0.030197484	0.012569	2.40	0.02
	[Gold].beta1	0.965730168	0.009189	105.10	0.00
	[Gold].shape	4.702961594	1.859535	2.53	0.01
Dollar Index	[Dxy].mu	6.88737E-05	5.31E-05	1.30	0.20
	[Dxy].omega	3.60486E-08	3.74E-07	0.10	0.92
	[Dxy].alpha1	0.046571983	0.008061	5.78	0.00
	[Dxy].beta1	0.951365182	0.007904	120.37	0.00
	[Dxy].shape	9.149791357	1.451915	6.30	0.00
NASDAQ Stock Exchange	[Nasdaq].mu	0.001269245	0.000159	7.97	0.00
	[Nasdaq].omega	3.62759E-06	2.08E-06	1.74	0.08
	[Nasdaq].alpha1	0.165999996	0.027411	6.06	0.00
	[Nasdaq].beta1	0.820851371	0.029324	27.99	0.00
	[Nasdaq].shape	6.162466595	0.707595	8.71	0.00
Euro to Dollar Exchange Rate	[EURUSD].mu	-9.63051E-05	8.16E-05	-1.18	0.24
	[EURUSD].omega	6.68167E-08	7.9E-07	0.08	0.93
	[EURUSD].alpha1	0.039133419	0.009281	4.22	0.00
	[EURUSD].beta1	0.959286299	0.007095	135.20	0.00
	[EURUSD].shape	8.92865073	3.347183	2.67	0.01
Conditional correlation parameters	[Joint]dcca1	0.019861196	0.002815	7.06	0.00
	[Joint]dccb1	0.959007127	0.007896	121.45	0.00
	[Joint]mshape	7.887519553	0.374889	21.04	0.00

Table 4. The weights obtained from the hierarchical analysis process

Index	Obtained weight
Brent Crude Oil	0.170
Gold (in troy ounces)	0.369
Dollar Index	0.222
NASDAQ Stock Exchange	0.065
Euro to Dollar Exchange Rate	0.174

During the time periods when shocks resulting from significant news and events occur in financial markets, the stress index also quickly responds and reflects the current market turbulence. The details of each of the events that took place during these periods are as follows:

Sep 2015: On this date, the migrant crisis to Europe unfolded, with train stations being blocked in Budapest, Hungary, preventing migrants from entering the country.

Feb 2016: During this time period, competition and presidential elections in the United States were underway, causing turbulence in financial markets.

Dec 2016: In this time period, the President of the United States had a telephone conversation with the leader of Taiwan, discussing the end of the "One China" policy in the country.

Dec 2018: During this time period, Emmanuel Macron, the President of France, announced an increase in minimum wages and tax exemptions after weeks of domestic unrest. Additionally, Theresa May, the Prime Minister of the United Kingdom, canceled the "Brexit" bill in the country's parliament.

Sep 2019: In this time frame, 50,000 workers from General Motors in the United States went on strike due to issues related to wages and benefits, as well as factory shutdowns.

Apr 2020: During this time period, the COVID-19 virus outbreak was declared a global pandemic, becoming a crisis in many countries around the world.

Mar 2022: In this time period, the Federal Reserve of the United States, for the first time since 2018, increased the interest rate by one-fourth of a point to help combat rising prices and inflation.

As observed, the highest level of stress in financial markets is associated with the COVID-19 pandemic in 2020.

Considering the significant values obtained for the parameters as shown in Table (4-12), it can be observed that the parameter A matrix with a value of 0.020123 has a significance level greater than 0.05, indicating its lack of significance. On the other hand, the significant values of the parameters in matrix B are both statistically significant.

Table 5. The results of the structural vector autoregression model

Parameter	Estimated coefficient	Standard error	Statistics	Sig. level
C(1)	0.020123	.011566	1.739894	0.0819
C(2)	-6 5.33E	-8 7.62E	69.91424	<0.01
C(3)	-6 3.05E	-8 4.36E	69.91422	<0.01

Analysis of the Dynamic Relationship between the Stress Index and the Fear Index (VIX)

In this section, an analysis and examination of the relationship between the stress index designed in this study and the well-known VIX index is conducted. This index is calculated on a daily basis as a percentage. To provide better visual representation in this study, the VIX index is first transformed from a percentage scale to the scale of the studied stress index using the Min-Max method, as evident in Figure (1). (It should be noted that data related to the VIX index was extracted from Yahoo Finance.)

From the above figure, it can be observed that the behavioral movement of the VIX index and the stress index designed in this study are quite similar. To investigate the causality of the behavior of these two indices, Granger causality tests are employed, and the results are presented in Table (8). In this study, the Granger causality test is conducted using a two-variable VAR model. Therefore, to specify the VAR model, the optimal lag length is first determined. The stationarity test results for the two indices are provided in Table (6), and the optimal lag length for the VAR model is presented in Table (7).

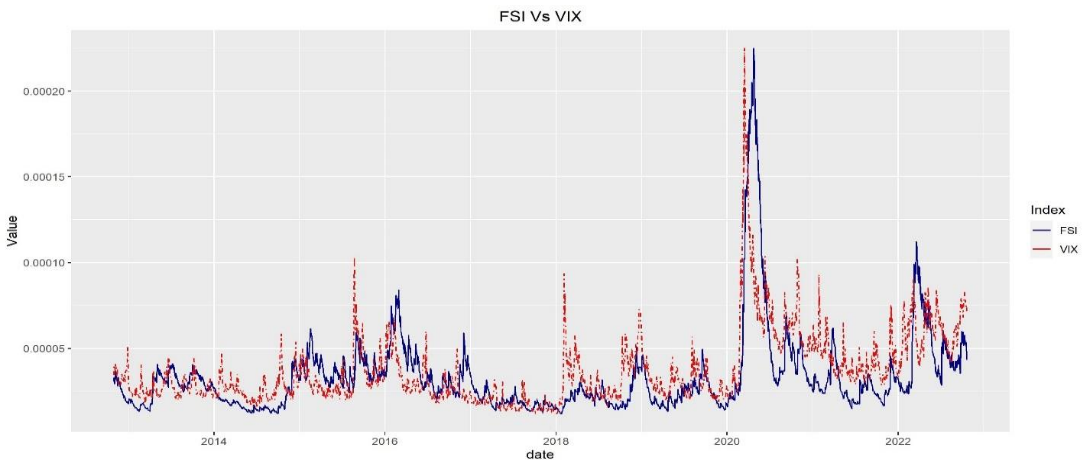

Figure (1): Charts of the Designed Stress Index and the VIX Index

Table 6. Results of the Augmented Dickey-Fuller Unit Root Test (Extended)

Index	Test statistics	Sig. level	Result
FSI	-5.45529	<0.01	Stationary
VIX	-5.77029	<0.01	Stationary

Table 7. Optimal lag length for VAR model

Lags	Akaike criterion	Hannan-Quinn criterion	schwarz criterion
Selected optimal lag	**5**	**5**	**2**
1	-49.6243	-49.6191	-49.61
2	-49.6604	-49.6518	**-49.6367**
3	-49.6583	-49.6463	-49.6251
4	-49.6707	-49.6552	-49.6279
5	-49.679	-49.66	-49.6267
6	-49.6779	-49.6555	-49.6161
7	-49.6768	-49.6509	-49.6055
8	-49.6761	-49.6468	-49.5953

Table 8. Results of the Granger Causality Test at a 5% significance level

Direction of causality	Statistics	Degree of freedom	Sig. level	Status
FSI to VIX	44.973	5	<0.01	Significant causality
VIX to FSI	0.6537	5	0.6587	Insignificant

According to Table (7), the optimal lag of 5 was identified based on the Akaike Information Criterion (AIC). (The reason for relying on AIC is the relatively large number of observations in the time series.) After modeling VAR(5), the results of the Granger Causality Test were applied, as shown in Table (8), indicating significant causality from the VIX index to the stress index. However, the reverse is not significant, so this causality is one-way.

Based on the above Granger causality test results, a Structural Vector Autoregression (SVAR) model wasused to analyze the dynamic relationship between these two indices. The obtained values are presented below, and the dynamic relationship between these two indices was further investigated through Impulse Response Functions (IRF) plots.

Considering the significant parameter values obtained, as shown in Table (9), it is observed that the parameter in matrix A with a value of 0.020123 is statistically significant, as it exceeds 0.05, indicating its significance. On the other hand, both parameters in matrix B are statistically significant. To investigate the dynamic response of the stress index to a one-standard-deviation shock to the VIX index over a 30-day period, it has been observed that a shock to the VIX index has a positive effect on the stress index defined in this study. In other words, an increase in the VIX fear index leads to an increase in the stress index defined in this research.

Table 9. Results of the Structural Vector Autoregression Model

Parameter	Estimation coefficient	Standard error	Statistics	Sig. level
C(1)	0.020123	.011566	1.739894	0.0819
C(2)	-6 5.33E	-8 7.62E	69.91424	<0.01
C(3)	-6 3.05E	-8 4.36E	69.91422	<0.01

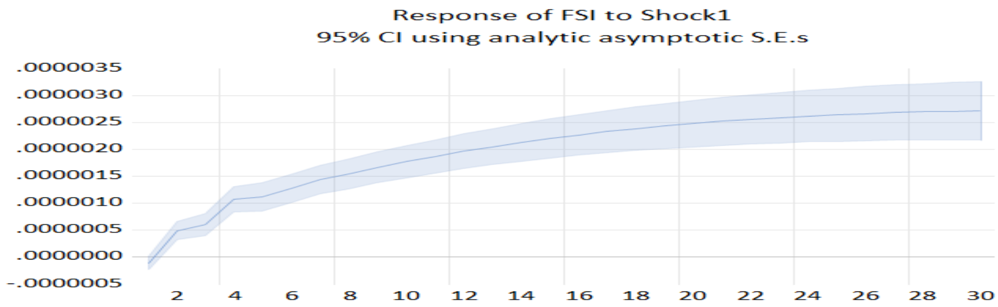

Figure 2. Instantaneous reaction function of the stress index to changes in the VIX fear index

General Analysis

Initially, a comprehensive understanding of the descriptive statistics of the data was obtained regarding the behavior and descriptive nature of the variables involved in constructing the stress index. Subsequently, using the multivariate GARCH model, the conditional volatilities of each variable were calculated and used as sub-indices in the main index formula based on the methodology of Halo and colleagues. To determine the weights of each sub-index, a hierarchical analysis approach based on expert opinions in financial markets was employed. Finally, after constructing the stress index, its dynamic relationship with the VIX fear index was examined and analyzed. Additionally, the causality between this index and the volatility of stock and currency markets in Iran was investigated. The findings indicated a dynamic positive relationship between the designed stress index and the VIX fear index.

Conclusions and Recommendations

Economic shocks are common in financial markets. Sometimes these shocks are created due to emotional and reckless news which can cause fear and anxiety in the decision-making process of investors and obviously fluctuations in financial markets. Meanwhile, if we want to name some important and effective indicators that are causeing chaos in the global markets, US dollar will definitely be one of the main factors. This index itself has the power to influence all financial markets in the world. The news that is published about the US dollar can direct the global financial markets, and has a great impact on the behavior of investors and causes stress or shock. In the classification of market risks, news is considered among the systematic risks that the investor cannot control or remove, that is why it is also called non-removable risk. This risk is one of the topics that have always existed in financial markets and some investors refer to it as market risk. In this research, important global variables such as gold, Brent oil, US dollar index, Nasdaq stock index and Euro-dollar exchange rate have been used to generate an index, which is affected by changes in the US dollar, so that a proper perspective can be given to financial providers for investing in global financial markets. All variables used in this study are quantitative and represent daily time series data from October 31, 2012, to October 21, 2022, after cleansing and aligning the historical dates for modeling purposes. In this study, five important global indices were used for constructing the financial stress index.

By examining concentration measures (mean and median), it is observed that the daily return of the TEDPIX index has higher average returns (0.05%) and medians (0.12%) compared to the other indices studied. On the other hand, looking at the standard deviation values of index returns, the lowest value is associated with the dollar index with a value of 0.0031, indicating that this index has relatively lower risk compared to the others. Furthermore, the highest standard deviation is related to the Brent oil index with a value of 0.03, indicating higher volatility and risk for this index compared to the others. Skewness values for all variables (with minor exceptions for Brent oil) are in the range (-2, 2), which suggests that the distribution of these three variables can be considered relatively symmetric. However, considering the positive and greater than 3 values of kurtosis, it can be concluded that the distribution peaks are sharper and more leptokurtic compared to the normal distribution.

Based on the results obtained, the t-Student distribution seems to be more suitable for these three variables than the normal distribution. Furthermore, the augmented Dickey-Fuller unit root test was used to check the stationarity assumption of currency returns. The calculated test statistics for the returns of Brent oil, gold, the dollar index, the TEDPIX index, and the EUR/USD exchange rate were -11.10, -13.47, -13.22, -13.42, and -14.29, respectively, with significant p-values less than 0.01 for each one. Therefore, the stationarity assumption of the returns of all five indices studied is accepted.

Regarding the results of the ARCH effects (heteroscedasticity) test, the test statistics for the returns of Brent oil, gold, the dollar index, the TEDPIX index, and the EUR/USD exchange rate were 474.38, 89.64, 167.07, 803.31, and 153.80, respectively, with significant p-values less than 0.01 for each one. Therefore, the assumption of the presence of ARCH effects or heteroscedasticity in the returns of each of the currencies is accepted.

In this study, the conditional volatilities were obtained from the multivariate GARCH model using the dynamic conditional correlation (DCC) approach. The p-value obtained was less than 0.01, indicating the rejection of the null hypothesis of constant correlation at the 99% level. Therefore, the alternative hypothesis of dynamic correlation was accepted, which is somewhat consistent with the DCC-GARCH approach employed. In all cases, the sum of alpha1 and beta1 is greater than 0.9, indicating high stability in conditional variances in the time series of returns for these currencies. Moreover, in all cases, the sum of these two parameters is less than one, indicating finite conditional variances and strong persistence.

The positive value of parameter *a* suggests that after a shock in the returns series of the indices, an increase in conditional correlation can be expected for the next period. Parameter *b* in the DCC model also indicates the effect of the previous period's conditional correlation on the current period's conditional correlation. The closer this parameter is to 1, the closer the conditional correlations between pairs of variables calculated are to the conditional correlations of the previous period.

Based on the findings, it was observed that the correlation between oil and gold indices has mostly been positive on most days, except for a few isolated cases where it has been around -0.2. Since 2022, we have also witnessed a positive correlation increase between these two indices, reaching up to 0.4. Notably, there is a consistently negative correlation between the Brent crude oil index and the dollar index over the entire historical period. The only exception is in 2022 when there is a brief period of daily correlation exceeding zero. On the other hand, the correlation between 2016 and 2017 drops below -0.4 and reaches nearly -0.5. The findings demonstrate that the conditional correlation between oil and the NASDAQ index has mostly been positive over time, with the maximum value of this correlation being around 0.4 during this period. The results also show that the conditional correlation between oil and the Euro to Dollar exchange rate has been oscillating within a range of approximately -0.3 to 0.3 over time and has been quite visible since mid-2022.

The findings show that the conditional correlation between gold and the Euro to Dollar exchange rate has been observed over time. Although there is an initial brief downward spike in early 2022 due to a shock to these markets, the correlation between these two indices has been mostly positive on most days over time. The analysis of the research reveals that the conditional correlation between the dollar index and the NASDAQ index over time indicates that, for the most part, there has been a negative correlation between these two indices, fluctuating within the range of 0 to -0.4. Furthermore, the findings demonstrate that the conditional correlation between the dollar index and the Euro to Dollar exchange rate reveals a relatively strong inverse correlation between these two indices. This correlation has been evident in several time periods, with values falling below -0.8, particularly intensifying since 2022. The results of the analysis also indicate that the conditional correlation between the NASDAQ index and the Euro to Dollar exchange rate has been fluctuating between -0.3 to 0.3 over time and has shown a noticeable positive shift since mid-2022.

Analysis of research hypothesis

The hypothesis of this research is stated as follows: There is a meaningful relationship between the VIX fear index and the financial stress index designed in this study.

Using the findings of the research, the designed stress index and the VIX index, it is observed that the behavioral movement of the VIX index and the designed stress index in this study are almost similar. Furthermore, according to causality, a meaningful relationship exists from the VIX index to the designed stress index. However, the reverse is not significant; therefore, this causality is one-sided. The research findings indicate that the reaction of the designed stress index to a shock in the VIX index is shown as a standard deviation shock. As observed, a shock in the VIX index has a positive effect on the designed stress index. In other words, an increase in the VIX fear index leads to an increase in the designed stress index. The results of the Granger causality test reveal that causality is one-sided from the designed stress index towards stock market turmoil. Therefore, the results of this research are in line with the studies of Kanas and Kouretas (2017), Sagi (2018), Shehadeh, Li, and Arize (2019), Li and Tao (2020), and Caporale and Plastun (2021).

Weighting the Variables through AHP

The result of weighting the research variables using the Analytic Hierarchy Process (AHP) technique indicates that the gold price has the highest weight of 0.369, followed by the dollar index with 0.222, the Euro to Dollar exchange rate with 0.174, Brent oil index with 0.170, and the NASDAQ index with 0.065, ranked fourth and fifth, respectively.

Practical Recommendations for the Hypothesis

- Regularly monitor the VIX volatility index and the financial stress index in Iran, staying updated on their movements, trends, and changes over time. This can provide valuable insights into market fluctuations and overall stress levels in the Iranian market.
- Utilize the VIX volatility index and the financial stress index as risk indicators. When these indices show an increase or reach high levels, it may indicate higher market volatility and financial stress. Therefore, investors can adjust their investment strategies and risk management approaches accordingly.
- Diversify investment portfolios to mitigate the impact of market fluctuations and financial stress. By distributing investments across different asset classes, sectors, and geographical regions, investors can reduce potential risks associated with the significant relationship between the VIX volatility index and the financial stress index.
- Explore risk hedging strategies to protect portfolios against potential adverse market movements and financial stress. Options, futures contracts, or other derivative instruments can be used for protection against unfavorable market developments. Consult with a financial advisor to determine the most suitable risk hedging approach for investment goals and risk tolerance.
- Align investment horizons and risk appetite with the significant relationship between the VIX volatility index and the financial stress index. For investors with shorter investment horizons or lower risk tolerance, consider more conservative investment strategies to mitigate potential losses during periods of high market volatility and financial stress.
- Establish appropriate mechanisms for information disclosure and dissemination, along with adequate education regarding financial innovations. This can not only enhance the efficiency of the financial market but also reduce the likelihood of making investment decisions based on sudden index fluctuations.
- Policy makers should address structural and political instability within the country as it can impact economic growth and performance. By examining various aspects of financial stress and political risk, they can work towards reducing the negative effects of these risks on the country's economic performance and taking steps to improve growth and economic performance in Iran.

Therefore, the relationship between the VIX volatility index and the financial stress index in Iran can provide insights into market dynamics and risk levels. By following these practical recommendations, investors can make more informed decisions, manage risks more effectively, and align their investment strategies with the prevailing conditions in the Iranian market.

References

* Rahimi Baghi, A., Arab Salehi, M., & Vaez Borzani, M. (2019). Systemic Risk Assessment in the Country's Financial System Using the Granger Causality Network Method. Financial Research, 21(1), 121-142.
* Rezazadeh, R., & Fallah Shams, M. (2020). Investigating the Spillover of Financial Stress Index Fluctuations on Inflation, Interest Rate, Liquidity, and Industry Index with Emphasis on GARCH-BEKK, VAR, and Granger Causality Models. Journal of Financial Engineering and Portfolio Management, 11(42), 272-301.
* Rezaei, M. (2018). Evaluation, Causes, and Major Consequences of the Economic Crisis in Iran. Journal of Financial Economics (Financial Economics and Development), 12(42), 201-226.
* Ghaffari Gol Afshani, R., Fallah, M. F., Safa, M. M., Mozhkani, M. S., & Jahanegirnia, H. (2023).
* Aliyu, S. U. R. (2009). Impact of oil price shock and exchange rate volatility on economic growth in Nigeria: An empirical investigation.
* Andersen, T. G., & Bondarenko, O. (2007). Construction and interpretation of model-free implied volatility.
* Beckmann, J., Berger, T., & Czudaj, R. (2019). Gold price dynamics and the role of uncertainty. Quantitative Finance, 19(4), 663-681
* Britten-Jones, M., & Neuberger, A. (2000). Option prices, implied price processes, and stochastic volatility. The journal of Finance, 55(2), 839-866.
* Caporale, G. M., & Plastun, A. (2021). Dynamic Relationship between Financial Stress and the VIX Index. International Review of Financial Analysis, 76, 101786.
* Cox, J. C., & Rubinstein, M. (1985). Options markets. Prentice Hall.
* Engle, R. F. (2002). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica: Journal of the econometric society, 987-1007.
* Grable, J., & Lytton, R. H. (2021). Financial risk tolerance revisited: the development of a risk assessment instrument☆. Financial services review, 8(3), 163-181.
* Gastineau, G. L. (1977). An index of listed option premiums. Financial Analysts Journal, 33(3), 70-75.
* He, X., Mishra, S., Aman, A., Shahbaz, M., Razzaq, A., & Sharif, A. (2023). The linkage between clean energy stocks and the fluctuations in oil price and financial stress in the US and Europe? Evidence from QARDL approach. Resources Policy, 72, 102021.
* Hollo, D., Kremer, M., & Lo Duca, M. (2012). CISS-a composite indicator of systemic stress in the financial system.
* Iqbal, N., Naeem, M. A., & Suleman, M. T. (2022). Quantifying the asymmetric spillovers in sustainable investments. Journal of International Financial Markets, Institutions and Money, 77, 101480.
* Ishrakieh, L. M., Dagher, L., & El Hariri, S. (2023). A financial stress index for a highly dollarized developing country: The case of Lebanon. Central Bank Review, 20(2), 43-52.
* Jiang, G. J., & Tian, Y. S. (2005). The model-free implied volatility and its information content. The Review of Financial Studies, 18(4), 1305-1342.
* Kanas, A., & Kouretas, G. P. (2017). The Relationship Between the VIX and the Financial Stress Index: Evidence from Global Financial Markets. International Review of Financial Analysis, 52, 9-26.
* Li, Y., Liang, C., & Huynh, T. L. D. (2023). Combination forecast based on financial stress categories for global equity market volatility: the evidence during the COVID-19 and the global financial crisis periods. Applied Economics, 1-36.
* Illing, M., & Liu, Y. (2016). Measuring financial stress in a developed country: An application to Canada. Journal of Financial stability, 2(3), 243-265.
* Mezghani, T., & Abbes, M. B. (2022). Forecast the Role of GCC Financial Stress on Oil Market and GCC Financial Markets Using Convolutional Neural Networks. Asia-Pacific Financial Markets, 1-26.
* Nura, T., & Korkmazb, T. (2022). Volatility spillover between Bitcoin and financial stress index. Journal of Corporate Governance, Insırance, and Risk Management, 9(1), 49-70.
* Ozcelebi, Oguzhan. (2023). Assessing the impacts of financial stress index of developed countries on the exchange market pressure index of emerging countries, International Review of Economics

& Finance, Volume 70, November 2020, Pages 288-302

* Omrane, W. B., & Savaşer, T. (2017). Exchange rate volatility response to macroeconomic news during the global financial crisis. International Review of Financial Analysis, 52, 130-143.
* Rawhouser, H., Vismara, S., & Kshetri, N. (2023). Blockchain and vulnerable entrepreneurial ecosystems. Entrepreneurship & Regional Development, 1-26.
* Rezazadeh, A., & Mohseninia, R. (2022). The Impact of Financial Stress on Gold, Currency and Stock Markets in Iran: Time-Varying Granger-Causality Approach. Iranian Journal of Economic Studies, 10(2), 365-390.
* Sagi, J. S. (2018). The VIX, the Variance Premium, and Stock Market Volatility. The Review of Financial Studies, 31(8), 2943-2991
* Settembre-Blundo, D., González-Sánchez, R., Medina-Salgado, S., &García-Muiña, F. E. (2022). Flexibility and resilience in corporate decisionmaking: a new sustainability-based risk management system in uncertaintimes. Global Journal of Flexible Systems Management, 22(Suppl 2), 107-132.
* Sook-Rei Tan, Changtai Li,(2022). Xiu Wei Yeap,A time-varying copula approach for constructing a daily financial systemicstress index,The North American Journal of Economics and Finance,Volume 63,
* Shehadeh, A., Li, Y., & Arize, A. C. (2019). The Interaction between the VIX Index and the Financial Stress Index in US and UK Markets. Review of Quantitative Finance and Accounting, 53(2), 413-438.
* Shim, S., Serido, J., & Tang, C. (2013). After the global financial crash: Individual factors differentiating young adult consumers' trust in banks and financial institutions. Journal of Retailing and Consumer Services, 20(1), 26-33.
* Wang, C., Wang, D., Abbas, J., Duan, K., & Mubeen, R. (2021). Global financial crisis, smart lockdown strategies, and the COVID-19 spillover impacts: A global perspective implications from Southeast Asia. Frontiers in Psychiatry, 12, 643783.
* Yildirim, Z., & Arifli, A. (2021). Oil price shocks, exchange rate and macroeconomic fluctuations in a small oil-exporting economy. Energy, 219, 119527.