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Examining the relationship between economic policy uncertainty and systemic banking risk in Iran's economy

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Abstract

The present study examines the relationship between economic policy uncertainty and systemic banking risk. For this purpose, the systemic banking risk was initially estimated using the Conditional Value at Risk ($\Delta CoVaR$) metric over 2011-2021 for 17 banks listed on the stock market. The results indicate that Ayandeh Bank has the highest systemic risk, while Eghtesad Novin Bank has the lowest systemic risk. Subsequently, the effect of economic policy uncertainty, along with other banking and macroeconomic variables, on systemic banking risk was analyzed using the system generalized method of moments (GMM). The results show that economic policy uncertainty leads to an increase in systemic banking risk. Therefore, to reduce systemic banking risk and prevent crises, it is necessary to avoid shocks and uncertainty as much as possible. Additionally, the variables of the debt-to-net-assets ratio of banks and gross loans as a percentage of total bank assets have the most significant impact on increasing systemic risk. Hence, monitoring and controlling the level of lending and reducing default risk can lead to a decrease in systemic banking risk. The return on assets and total loan loss reserves divided by the gross value of loans have the most significant impact on reducing systemic risk. Therefore, diversifying assets and maintaining adequate reserves for crisis conditions, where the likelihood of loan defaults is higher, play a significant role in improving the conditions of banks and reducing the risks of loan defaults and systemic risk in the banking network.

Keywords: systemic bank risk, economic policy uncertainty, conditional value at risk, system generalized method of moments
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1 Introduction

The occurrence of financial crises, which have increased in recent years, has led to greater attention being paid to systemic risk in financial institutions. A review of financial crises worldwide shows that the most significant threat to financial stability is systemic risk arising from banking system crises [39]. Notably, after the global financial crisis of 2008, which originated in financial markets, studies on systemic risk have gained more attention from researchers. The global financial crisis highlighted that if banking supervision is limited to individual financial institutions, it

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may lead to overlooking the role each institution plays in contributing to systemic risk [22]. It can be stated that banks and systemic risk in banks are influenced by various factors, one of which is the policies implemented by the government and the central bank. Among these, the occurrence of shocks and uncertainty regarding economic policies causes economic actors to become uncertain about future economic developments. Consequently, since investors are unable to make decisions about the future, financial markets will face difficulties [5]. One of the most important financial markets, especially in Iran, is the banking market. Iran's financial system is bank-centered, and banks play a significant role in financing the Iranian economy [47]. Therefore, an increase in economic policy uncertainty (EPU) can significantly increase the systemic risk of Iranian banks. Given the rise in uncertainty and crises in recent years, it is essential to study this role extensively.

Banks may experience higher systemic risk during periods of high economic policy uncertainty (EPU) for various reasons. On one hand, EPU can directly affect the behaviour and business decisions of banks. EPU not only hinders bank credit growth but also leads to more serious information asymmetry between banks and borrowers, resulting in irrational allocation of bank loan resources. This issue leads to reduced bank revenue and increased defaulted loans [23]. On the other hand, EPU can indirectly impact banks by affecting companies and households. EPU can cause companies to have uncertain expectations regarding government policies, consequently reducing investment, employment, and production [9]. Reduced investment and production lead to significant revenue declines for firms, and household income volatility significantly increases due to higher unemployment and reduced new hires. As a result, companies and households may be unable to service their debts, leading to a significant increase in the likelihood of defaults [12]. In this situation, banks will face more serious credit risks and may be unable to fully recover their loans. The number of defaulted loans will increase, leading to a reduction in bank revenue [13]. These effects on the bank's assets and income ultimately harm the bank's profitability, debt servicing ability, and capital, thereby increasing systemic vulnerability [25].

On the other hand, economic policy uncertainty (EPU) may have a mitigating effect on systemic banking risk. Since the 2008 financial crisis, significant reforms in supervision and risk management have strengthened the banking system's resilience against negative impacts. Moreover, during periods of high EPU, companies and banks may make timely adjustments to their risk behaviour, reduce risky investments, and hold more secure assets, thereby reducing loan defaults and systemic vulnerability. Therefore, understanding how EPU affects systemic banking risk is a topic that warrants further discussion [25].

In Iran as well, high economic policy uncertainty (EPU) can have diverse effects on systemic banking risk. Particularly in recent years, EPU has been accompanied by high and volatile inflation, intensifying its impact on systemic risk. High inflation can reduce savings due to real interest rates turning negative, and it can decrease domestic financial resources available to producers because of economic downturns and fluctuating conditions. This situation leads to increased demand for loans to finance production. However, banks may be less inclined to lend due to reduced financial resources and the increased likelihood of loan defaults amid adverse economic conditions. These factors contribute to reduced production, increased unemployment, lower household income, and decreased producer revenues. Consequently, individuals' ability to repay existing loans diminishes, increasing the risk of defaults and thereby escalating systemic banking risk. On the other hand, as seen in previous years, banks in Iran may still be able to mitigate systemic risk through government assistance or timely and prudent decisions to diversify their assets. Additionally, the banking structure might be such that EPU and economic fluctuations have minimal impact on systemic banking risk. Therefore, the current study aims to investigate the following question: What impact does EPU have on systemic risk in banks listed on the Iranian Stock Exchange?

To address the current research question, using data from selected stock exchange-listed banks during the period 2011-2021, systemic banking risk is initially calculated using the $\Delta CoVaR$ method. Subsequently, the systemic effect of Economic Policy Uncertainty (EPU), alongside other selected variables, is examined using the System Generalized Method of Moments (GMM).

Theoretical foundations and background related to the present research will be reviewed further. The research methodology will be presented in Section 3. Findings will be discussed in Section 4, and conclusions and recommendations will be provided in Section 5.

2 Theoretical foundations

2.1 Theoretical literature

2.1.1 Definition of systemic risk and various measurement methods

There are various definitions of systemic risk briefly mentioned here. One definition refers to systemic risk as a set of conditions that threaten the stability, resilience, and public trust in the financial system [15]. The European Central Bank defines systemic risk as a risk that, if materialized, would impair the functioning of the financial system, thereby reducing economic growth and welfare levels [27]. The European Systemic Risk Board defines systemic risk as the risk of disruption to financial services due to damage to the financial system, with potential adverse effects on the domestic market and the real economy [1]. Systemic risk is defined as an external risk that threatens the entire financial system and national economy. The Bank for International Settlements describes systemic risk as the risk of disruption to financial services due to general or partial damage to the financial system, and the potential adverse effects on the economy [7].

There are various methods for measuring systemic risk and the associated propagation effects, which are generally referred to as follows. The first method is derived from the Minimum Efficiency Scale (MES) method [42], the Systemic Risk Index (SRISK) method [17], the Conditional Expected Shortfall (CES) cost method [11], and other methods of measuring capital loss based on Expected Shortfall (ES). SRISK measures the shortfall of expected capital of a financial institution during systemic crises, representing the difference between the capital required for regulatory compliance or prudent operations and the actual value of shareholders' equity. CES calculates the expected loss at the end of a tail under extreme conditions. Given the assumption that the banking system bears severe losses overall, CES measures a bank's contribution to systemic banking risk [11].

The second method, based on spill-over effects, utilizes Value at Risk (VaR) to determine the maximum possible losses in a specified investment portfolio over a certain period. It employs conditional risk measures known as CoVaR (Conditional Value at Risk), which represent indices that are exposed to risk [2]. Copula-CoVaR [34] and semi-parametric CoVaR are examples of such methods. The third method, measuring model-driven systemic financial risk, is based on the Conditional Claims Analysis (CCA) approach. This method was first utilized by Gray and Jobst [31] and has since been broadly employed for systemic risk measurement [50].

2.1.2 Definition of economic policy uncertainty

Different definitions have been proposed for economic policy uncertainty, and some definitions are briefly mentioned in this section.

Economic policy uncertainty is a condition where the future trajectory of government policies is uncertain, leading to increased risk for economic activities, causing individuals and companies to delay decisions regarding investment, production, and expenditures. Economic policy uncertainty is defined as uncertainty associated with public policies, especially monetary and fiscal policies, affecting the economic environment in which businesses operate [44]. Economic policy uncertainty indicates a risk associated with uncertain governmental policy responses as an economic factor influencing customary legal actions. Ultimately, this prevents individuals and companies from making decisions, thereby delaying consumption and investment until uncertainty is resolved. Increased economic policy uncertainty leads to delays and reduced economic and commercial activities such as hiring, investment, and other forms of expenditures. It has also been noted that policy uncertainty revolves around discussions on taxes, expenditures, and monetary and regulatory policies [51].

Economic policies announced by governments, due to lack of transparency, ambiguity, and unpredictability, often confuse participants in economic activities or force governments to take a position contrary to the original intent of a policy, ultimately creating shocks of uncertainty. This type of uncertainty is considered as economic policy uncertainty (EPU). EPU can be characterized by features such as: unclear expectations created by frequent policy changes by governments [29]; the possibility that governments may adopt a stance opposing implemented policies [36]; and new policies implemented to the benefit of the private sector [43].

2.1.3 The impact of economic policy uncertainty on systemic risk

Wu et al. [49] noted that depending on how bank managers respond to policy uncertainty, there may be two opposing effects on banks' risk-taking behaviors. On one hand, a bank may adopt a "wait-and-see" strategy in times of uncertainty, thereby preserving liquidity and reducing risk appetite [14]. Ng et al. [40] stated that if a bank manager pursues capital and income management, when faced with significant economic policy uncertainty issues, policy uncertainty correlates negatively with loan loss reserves. Reductions in previous risk-taking behaviors will lead to further decreases in future risk-taking indicators.

On the other hand, economic policy uncertainty increases banking risk due to the "search for yield" strategy. Increased economic policy uncertainty raises non-performing loans in banks [21]. If bank managers understand policy uncertainty and anticipate recessionary effects, they may seek higher returns by investing in new projects to offset potential credit risks. Higher returns may entail greater future risks [28]. Therefore, based on the literature, economic policy uncertainty can have two opposing effects on systemic banking risk, and this study examines how uncertainty impacts systemic banking risk in Iran.

2.1.4 Factors affecting systemic risk

Since the financial crisis, researchers have conducted numerous studies on the determinants of systemic risk. Some studies examine precise determinants of systemic risk in conjunction with bank financial indicators. For instance, Varotto and Zhao [48] found a significant positive correlation between bank size and systemic risk. The reason behind this is that large banks are irreplaceable in the economic and financial system and often take priority for government assistance during crises, but they are also more exposed to moral hazard issues. Furthermore, empirical studies have shown that the debt-to-net asset ratio, non-interest income ratio, loan loss reserves, total long-term debt ratio, and ownership structure affect bank systemic risk [16]. However, many studies indicate that systemic risk is determined not only by internal bank-specific factors but also influenced by macroeconomic factors within the country. For example, Brunnermeier et al. [18] found that the formation and bursting of asset price bubbles in real estate and equity markets significantly increase systemic risk in the country. Chen et al. [20] discovered that stringent banking supervision exacerbates banks' capital shortages and leads to greater banking systemic risk. Therefore, alongside EPU (Economic Policy Uncertainty), the present study also examines the impact of various influential factors on banking systemic risk in Iran.

2.2 Research background

Berger et al. [14] examined the impact of economic policy uncertainty (EPU) on bank liquidity reserves in their study, creating a comprehensive measure of bank liquidity reserves that considers assets, liabilities, and off-balance sheet activities. Using over one million quarterly bank observations, their findings indicate that in response to EPU, banks generally increase liquidity reserves across all three components. This behavior is more pronounced for banks with lower liquidity, higher spillover effects from peer banks, and greater exposure to EPU.

Duan et al. [25] investigated the effect of economic policy uncertainty (EPU) on banking systemic risk for twenty countries using an OLS model with fixed effects. Their empirical results indicate that an increase in EPU leads to an increase in systemic risk.

Fang et al. [28] examined the impact of economic policy uncertainty (EPU) on banking systemic risk, distinguishing between systemic linkages and bank-specific risk. Using bank-level data from 25 countries over the period 2010-2020, their results indicate strong and consistent evidence that policy uncertainty is negatively associated with bank-specific risk but positively related to systemic linkages. When policy uncertainty manifests, banks tend to engage in activities with lower risk, reflecting more homogeneous business patterns observable in market performance.

Deng and Li [24] investigated how Economic Policy Uncertainty (EPU) affects two components of systemic risk (systemic linkages and idiosyncratic risk) using data from 60 countries spanning January 2006 to December 2021. They differentiated between the effects of global and domestic shocks from EPU. Their findings indicate that increases in global shocks lead to higher systemic linkages, whereas domestic uncertainty contributes to lower idiosyncratic risk. Additionally, cross-border bank loans and non-performing loans serve as channels through which EPU sequentially exerts negative effects.

Yang et al. [50] utilized the DCC-GARCH model to construct systemic risk indices and Principal Component Analysis to construct a macroeconomic shock index for monthly data from January 2007 to June 2022 across 45 registered financial institutions in China. They then employed the TVP-VAR-SV model to examine the relationship between Economic Policy Uncertainty (EPU), macroeconomic shocks, and systemic financial risk. Their results indicate clear time-varying relationships among economic policy uncertainty, macroeconomic shocks, and systemic financial risk.

Hekmati Farid et al. [33] estimated systemic risk in the financial sector using the Conditional Value-at-Risk (CVaR) differential approach and data from the banking, stock market, and insurance sectors during the years 1995-2015. Their analysis using quantile regression and post-hoc tests indicated significant differences in systemic risk across these financial subsectors: banking, insurance, and stock market. Furthermore, the results of Friedman ranking tests showed that the insurance industry contributed the most to systemic risk, while the banking sector had the least share in systemic risk creation.

Amiri and Pirdadeh Beyranvand [5] examined the effect of economic policy uncertainty on stock returns using linear and non-linear models during the period of 1981-2016 (Iranian calendar). The findings of the study indicate that economic policy uncertainty leads to a decrease in stock returns. Additionally, the relationship between stock market returns and economic policy uncertainty is non-linear, and the impact of uncertainty on stock returns is stronger and more persistent in high volatility regimes.

Hatef Vahid and Saleh Ardestani [32] focused on measuring systemic risk using the Markov clustering method and centrality-based risk measure. Their results demonstrated that the proposed method's efficiency was higher compared to centrality measures and the traditional CoVaR measure.

Ostad Hashemi et al. [41] investigated the impact of shocks in macroeconomic variables on systemic risk in the banking system using a Structural Vector Autoregression (SVAR) model on a quarterly basis during the period 1991-2017. The results indicate that positive shocks in oil prices, inflation uncertainty, exchange rates, and bank interest rates have an increasing effect on systemic risk. Conversely, positive economic growth is associated with a reduction in systemic risk.

Raei et al. [45] measured and decomposed the systemic risk index in banks listed on the stock exchange during the period 2013-2020. The research results indicate that Post Bank, Tejarat Bank, and Export Development Bank respectively have the highest systemic risk levels, while Kar Afarin Bank and Eghtesad Novin Bank have the lowest. Additionally, increasing bank size leads to a reduction in both systemic risk and its associated follow-up risk specific to each bank, while the systemic link index increases.

The current study innovates over previous research conducted in Iran in several aspects. Firstly, it distinguishes itself by incorporating balance sheet items and off-balance sheet ratios into the estimation of systemic risk using the $\Delta CoVaR$ method in the banking network. The closest studies to the current research include those by Hekmati Farid et al. [33] and Hatef Vahid et al. [32], which utilized some banking indicators such as annual return of the banking system, total assets, operational income, and equity for estimating systemic risk through the $\Delta CoVaR$ approach. However, none of these studies considered off-balance sheet items and the debt-to-asset ratio. This study is the first to include both balance sheet and off-balance sheet items of banks in estimating systemic risk using the $\Delta CoVaR$ method, which can provide a better estimation of systemic risk considering the impact of crises on both balance sheet and off-balance sheet items of banks.

Secondly, this study considers the impact of Economic Policy Uncertainty (EPU) on the systemic risk of banks. In fact, during crises, it is necessary to adopt policies aimed at reducing risk. However, due to crisis conditions, the implementation of these policies may be accompanied by uncertainty, which can have different effects compared to times when policies are certain and clear on systemic risk of banks. Therefore, the study examines the effect of EPU on systemic risk of banks, which has not been done in this manner before. Alongside the EPU variable, a set of control variables such as the debt-to-net asset ratio of banks, total assets of banks, average asset returns, and other bank-specific variables significantly affected by crises are considered. Additionally, macroeconomic variables such as CPI and the percentage change in nominal GDP, which are also influenced by crises and uncertainty, are included. These variables are considered to examine systemic risk of banks after estimation, evaluating how EPU and other control variables affect systemic risk of banks. Through detailed analysis of these variables, the study aims to inform sound policymaking for reducing systemic risk in the banking sector. To date, comprehensive studies incorporating influential variables in the banking system and macroeconomic variables have not been conducted in this area. Therefore, this study seeks to fill this gap by providing insights into how EPU and other control variables influence systemic risk of banks, enabling informed policymaking for effective systemic risk reduction in the banking sector.

3 Research methodology

3.1 Systemic risk

In the present study, the $\Delta CoVaR$ (Conditional Value at Risk) metric is used to estimate systemic risk. $\Delta CoVaR$ is a systemic risk indicator that considers a bank as a "risk producer" and measures the contribution of a financial institution to overall systemic risk by estimating the amount of risk added to the entire financial system during a crisis. This index is widely used in research related to systemic risk [37]. Systemic risk is typically built up during periods of low volatility and materializes during a crisis. An appropriate systemic risk measure should account for this increase. This implies that high-frequency risk measures, which mainly rely on simultaneous price movements, can potentially be misleading [2].

Adrian and Brunnermeier [2] propose $\Delta CoVaR$ as a measure of systemic risk for individual banks. This measure considers changes in the market value of banks' assets, defined as "the change in the conditional value at risk of the financial system conditional on an institution being in distress relative to its median state." Systemic risk captures the spillover of risk from banks to the financial system, which differs from previous studies that measured the stability of banks [30]. Previous studies have shown that banks with larger total assets, higher financial leverage, and lower loan portfolio quality exhibit higher systemic risk [2, 16]. This metric is crucial for assessing systemic risk in banks as it identifies the extent to which a crisis in a financial institution, such as a bank, impacts the entire financial system [39]. The model is expressed as follows:

$$X_{i,t} = \frac{ME_{i,t} \cdot LEV_{i,t} - ME_{i,t-1} \cdot LEV_{j,t-1}}{ME_{i,t-1} \cdot LEV_{i,t-1}} = \frac{A_{i,t} - A_{i,t-1}}{A_{i,t-1}} \tag{3.1}$$

Considering the present study, in equation (3.1), the independent variable for estimating systemic risk is denoted as X_i, representing the rate of change in the market value for bank i in Iran. $X_{i,t}$ includes information related to off-balance sheet items, which indicate derivative contracts that are not precisely recorded with the total accounting value of assets. $LEV_{i,t}$ represents the debt-to-net-assets ratio, $ME_{i,t}$ is the market value of equity, and $A_{i,t}$ is the market value of assets.

Systemic profit in Iran is defined as follows:

$$X_t = \sum_{i=1}^{N} X_{i,t} \cdot \left(\frac{A_{i,t-1}}{\sum_i^N A_{i,t-1}} \right) \tag{3.2}$$

In the next step, it is assumed that the return of each bank i and the return of Iran's financial systems follow a bivariate normal distribution.

$$(X_{i,t}, X_t) \sim N\left(0, \begin{pmatrix} (\sigma_{i,t})^2 & \rho_{i,t}\sigma_{i,t}\sigma_{j,t} \\ \rho_{i,t}\sigma_{i,t}\sigma_{j,t} & (\sigma_t)^2 \end{pmatrix}\right) \tag{3.3}$$

the variables $\sigma_{i,t}$ and σ_t represent the standard deviations of $X_{i,t}$ and X_t, respectively, and $\rho_{i,t}$ represents the dynamic correlation coefficient between $X_{i,t}$ and X_t. Using the DCC-GARCH(1,1) model to estimate these parameters, equations (3.4) and (3.5) can be written as follows.

$$VaR_{i,t}(q) = -\Phi^{-1}(q)\sigma_t \times 100 \tag{3.4}$$

$$\Delta CoVaR_{i,t}(q) = -\Phi^{-1}(q)\rho_{i,t}\sigma_t \times 100 \tag{3.5}$$

In this study, it is assumed that q = 0.05; therefore, $\Phi^{-1}(q) = -1.96$. To avoid the problem of comparing very small numerical values in the empirical analysis sample, the result of calculating $\Delta CoVaR$ is multiplied by -1.

The right side is multiplied by 100. Since a method based on market price information is used to calculate the systemic risk of banks, the sample is limited to banks listed on the stock exchange [25].

3.2 DCC-GARCH model

Engle [26] did not assume constant conditional correlations and introduced the DCC model, which is a dynamic conditional correlation model. In this model, the correlation matrix is allowed to change over time. In defining the matrix, there is not much difference between the DCC and CCC models, and in this model, the matrix is still a variance-covariance matrix.

$$\varepsilon_t|\phi_{t-1} \sim N(0, H_t) \sim N(0, D_t R_t D_t) \tag{3.6}$$
$$H_t = D_t R_t D_t$$

In the DCC model, the diagonal matrix of time-varying conditional volatilities (standard deviations), D_t, is similar to that in the CCC model and is extracted from a univariate GARCH process. In matrix notation, this can be rewritten as equation (3.7).

$$D_t^2 = diag(a_{0,i}) + diag(a_{1,i}) o \varepsilon_{t-1}\varepsilon'_{t-1} + diag(b_{1,j}) o D_{t-1}^2 \tag{3.7}$$

The operator o denotes the element-wise multiplication of matrices. Also, $u_t = D_t^{-1}\varepsilon_t$. The only difference between the DCC and CCC models is the time-varying nature of the conditional correlation matrix of residuals, R_t [22].

3.3 Model specification

In the present study, following the research of Duan et al. [25], the effect of Economic Policy Uncertainty (EPU) on systemic banking risk is considered. In the first part, as mentioned above, systemic risk is estimated. In the second part, the impact of EPU alongside other control variables on systemic risk is examined.

In the present study, to examine the effect of variables on systemic risk, Equation (3.8) and the System GMM model are used. This method provides solutions for some estimation problems such as short-term panel data, dynamic dependent variables, fixed effects, and the lack of suitable external instruments [46]. Using this method includes advantages such as not considering heteroscedasticity and eliminating biases present in cross-sectional regression. The GMM method is employed when the number of cross-sectional units (banks) is greater than the time period [10], which is the case in this study. The estimation is done using the Arellano and Bond [6] GMM method and the Eviews software.

$$Systemic\_Risk_{i,t} = \beta_1 EPU_t + \beta_2 Control_{i,t} + \varepsilon_{i,t} \tag{3.8}$$

where i represents the selected publicly traded banks in Iran and t represents the year. EPU_t indicates the economic policy uncertainty in Iran during time t for bank i. $Control_{i,t}$ is the vector of control variables. $\varepsilon_{i,t}$ is the random error term.

In the current study's regression analysis, a set of control variables has been included that previous research has shown to be associated with systemic risk, bank risk, and bank performance [18, 35]. These variables include CPI, percentage change in nominal Gross Domestic Product (GDP Change), total assets of the bank (Total Assets), leverage ratio (Leverage), average return on assets (ROA), rate of change in total assets of the bank (Asset Growth), gross loans as a percentage of total bank assets (LoanToAsset), total interest income divided by operating income (InterestRatio), total loan loss provisions divided by gross loan value (LLP), and the ratio of liquid assets to total deposits and funds (Liquidity).

Given the nature of economic policy uncertainty, researchers have relied on various methods to measure uncertainty. One method is based on the volatility of key economic and financial variables [38]. Another method involves text mining in newspaper archives, which assesses political and economic uncertainty indices along with geopolitical risk indices [19]. Other researchers have attempted to capture uncertainty regarding corporate sales outlooks [4] or consider indices of disparities or surprises [8]. However, despite their utility, these methods share a significant limitation: They are usually limited to a set of developed countries, and for a large number of countries, data are available only after 1990.

To address this problem, Ahir et al. [3] constructed a new index of uncertainty called the World Uncertainty Index (WUI) for 143 countries starting from 1952 on a quarterly basis. This index reflects the frequency of the word "uncertainty" (and its variants) in country reports from the Economist Intelligence Unit (EIU). To ensure comparability across countries, the raw count is adjusted based on the total number of words in each report—specifically, the count of the word "uncertainty" per thousand words [3]. In the present study, given the availability of data for Iran, the World Uncertainty Index developed by Ahir et al. [3] is used as a representative index of economic policy uncertainty (EPU).

In this study, data on EPU (Economic Policy Uncertainty) has been collected from the study by Ahir et al. [3]. CPI data and interest rates have been gathered from the Central Bank's time series website, while nominal GDP growth rates were collected from the Central Bank's national accounts. Other variables related to selected stock exchange banks were collected from the Codal website. The estimation in the current study utilizes information from 17 selected stock exchange banks over the period from 2011 to 2021.

4 Findings

4.1 Reliability of variables

In order to ensure that the estimation models are not spurious, it is necessary to test the reliability of variables. In the current study, the Im-Pesaran-Shin unit root test is used to examine the reliability of variables. The null hypothesis of this test is that the series contains a unit root, suggesting non-stationarity, while the alternative hypothesis is that the series is stationary. Table 1 presents the results of the unit root test for the variables.

According to the results in table 1, all the variables are reliable from the zero level.

Table 1: The results of reliability test of variables

Variables	Statistics	Possibility
Systemic Risk	-3.29	0.000
EPU	-6.91	0.000
CPI	-8.23	0.000
GDP Change	-6.98	0.000
Total Assets	-3.99	0.000
Leverage	-5.7	0.000
ROA	-11.36	0.000
Asset Grow	-2.23	0.000
LoanToAsset	-7.1	0.000
InterestRatio	-9.2	0.000
LLP	-6.3	0.000
Liquidity	-6.1	0.000

4.2 Systemic risk

Before interpreting the main model of the research, it is necessary to discuss some points regarding the overall systemic risk and the systemic risk for each of the listed banks in Iran. Table 2 presents the descriptive statistics of the overall systemic risk and the systemic risk for each bank.

Table 2: Descriptive statistics of systemic risk variable

Bank	Average	Standard deviation	Skewness	Kurtosis	Rank
Total systemic risk	0.646	1.35	2.874	14.787	
Dey Bank	0.828	1.732	1.256	2.802	3
Saman Bank	0.635	1.31	1.704	4.581	8
Sarmayeh Bank	0.543	1.232	1.291	2.939	11
Ayandeh Bank	0.906	1.585	1.676	4.57	1
Saderat bank	0.459	0.877	1.107	3.154	14
Mellat Bank	0.531	0.89	0.687	1.846	12
Parsian Bank	0.749	1.807	1.903	5.064	5
Pasargad Bank	0.777	1.504	1.490	3.659	4
Post Bank of Iran	0.688	1.253	1.231	2.769	6
Tejarat Bank	0.666	1.283	1.107	2.704	7
Middle East Bank	0.595	0.742	1.289	3.717	10
Iran Zamin Bank	0.498	0.756	0.894	2.135	13
Sina Bank	0.45	1.163	1.898	5.137	15
Kar Afarin Bank	0.419	0.741	0.835	2.556	16
Tourism Bank	0.613	3.597	1.595	3.979	9
The Melal Credit Institution (Melal Bank)	0.885	1.973	1.750	4.601	2
Eghtesad Novin Bank	0.339	0.612	0.786	2.32	17

Based on the results in Table 2, the following points can be stated.

1. The total systemic risk of the banking network has a mean of 0.646 and a standard deviation of 1.35, indicating high volatility in the systemic risk of the banking network as the standard deviation exceeds the mean. This observation holds true for the systemic risk of each individual bank as well. Therefore, increased supervision of banks is necessary to mitigate systemic risk. Furthermore, given the skewness and kurtosis, the distribution of systemic risk, both overall and for each bank, is not normal.
2. By examining the systemic risk for each bank, it can be stated that Ayandeh Bank, The Melal Credit Institution, Day Bank, Pasargad Bank, and Parsian Bank have the highest systemic risk. In fact, Ayandeh Bank, which has faced a higher level of loan defaults and non-repayments in recent years, also has a worse situation in terms of systemic risk. Government aid and support have not been able to resolve the banking risk issues for these indebted banks. This finding is consistent with the study by Zhang et al. [52], which indicated that lending to affiliated groups undermines the effectiveness of compensation incentives in commercial banks.
3. Among the banks, five banks—Eghtesad Novin, Kar Afarin, Sina, Saderat, and Iran Zamin—had the lowest banking risk. It can be stated that although Eghtesad Novin Bank also faced many issues related to loan defaults in previous years, these problems have been well managed, resulting in reduced systemic banking risk. Among the banks with low systemic risk, four out of five are considered small-sized banks based on the number of branches. This indicates that smaller banks, if they manage their assets and liabilities better, can have lower systemic risk even in crisis conditions. This finding is consistent with the study by Varotto and Zhao [48], which found that smaller banks have lower systemic risk.

4.3 Estimation of the research model

In table 3, the estimation results of the current research model using the systemic GMM method are presented.

Table 3: The estimation results of the systemic GMM model

Variables	**Coefficient**	**Standard deviation**	**t statistic**	**p-value**
Systemic Risk(-1)	0.17	0.047	3.63	0.000
EPU	0.018	0.01	1.76	0.08
CPI	0.146	0.03	4.95	0.000
GDP Change	-3.235	0.75	4.31	0.000
Total Assets	0.19	0.07	2.65	0.01
Leverage	1.49	0.6	2.45	0.01
ROA	-7.96	3.4	-2.36	0.02
Asset Grow	0.63	4.37	0.14	0.9
LoanToAsset	0.83	0.46	1.8	0.07
InterestRatio	-0.95	0.55	-1.72	0.09
LLP	-6.8	3.3	2.1	0.04
Liquidity	-0.02	0.01	-1.92	0.06
AR(1)	0.000	AR(2)	0.192	

The results indicate that systemic risk with a one-period lag (Systemic Risk(-1)) has a positive and significant effect at the 95% confidence level on systemic banking risk. Therefore, if the banking system enters a crisis and systemic risk increases, the crisis is not resolved in the short term, and systemic risk continues to rise in subsequent periods. Hence, it is necessary for authorities and regulators to implement policies to prevent the occurrence of banking crises and the increase of systemic banking risk as much as possible.

Economic Policy Uncertainty (EPU) has a positive and significant effect at the 90% confidence level on systemic banking risk. Therefore, economic policy uncertainty in Iran can increase systemic banking risk for various reasons, such as worsening economic conditions, the shutdown of various industries, the potential default on loans, mismanagement of banks, incorrect lending decisions during times of increased uncertainty, banks' tendency to engage in high-risk activities to enhance profitability, and insufficient oversight by responsible authorities. This finding is consistent with studies by Danisman et al. [23], Barua [12], and Beck and Keil [13], which found that economic policy uncertainty can increase systemic risk due to the heightened likelihood of loan defaults.

The inflation rate (CPI) has a positive and significant effect at the 95% confidence level on systemic risk. An increase in the inflation rate and expected inflation leads to a decrease in savings and a negative real interest rate in Iran. This results in individuals being less inclined to save and preferring to convert their money into other assets like real estate or foreign currency to preserve its value. These behaviors lead to a reduction in bank reserves and an increase in systemic banking risk. This finding is consistent with the studies by Duan et al. [25] and Abrishami et al. [1], which found that an increase in the inflation rate leads to an increase in systemic banking risk.

Changes in nominal GDP (GDP Change) have a significant and negative effect at the 95% confidence level on systemic banking risk. An increase in GDP leads to improved economic conditions and increased production across various industries, which in turn reduces the risk of default on loans granted by banks. Therefore, it significantly reduces systemic banking risk. This finding aligns with the studies by Duan et al. [25] and Ostad Hashemi et al. [41], which found that an increase in GDP reduces systemic banking risk.

Total Assets have a significant and positive effect on systemic risk at the 95% confidence level. An increase in a bank's assets and its size can lead to reduced control and oversight by the bank's management over all branches. This situation can result in investments in riskier assets across various branches, thereby increasing systemic risk overall for different banks. This heightened risk can lead to banking crises and an increase in the systemic risk of the entire banking system. Additionally, the growth rate of a bank's total assets (Asset Grow) also contributes to increased systemic risk; however, its effect is not significant.

The leverage ratio (Leverage) has a significant and positive effect on systemic banking risk at the 95% confidence level. Therefore, as the leverage ratio increases, the likelihood of a crisis and systemic risk also increases, particularly during times of heightened economic policy uncertainty. The ratio of gross loans to total bank assets (LoanToAsset) also increases systemic risk and is significant at the 90% confidence level. Hence, an increase in the loan-to-asset ratio, especially given the possibility of loan defaults during crises and periods of economic policy uncertainty, can lead to higher systemic risk.

The return on assets (ROA) significantly reduces systemic banking risk at the 95% confidence level. Therefore, diversifying bank assets and increasing asset returns can help reduce systemic risk. The ratio of total interest income to operating income (InterestRatio) also reduces systemic risk, with its effect being significant at the 90% confidence level. Additionally, the loan loss provisions divided by the gross value of loans (LLP) and the ratio of liquid assets to total deposits and funds (Liquidity) both reduce systemic banking risk, with LLP being significant at the 95% confidence level and Liquidity at the 90% confidence level. In essence, banks can reduce systemic risk by maintaining liquidity, reducing lending, or implementing stricter oversight on lending to minimize loan default risk and increase interest income. These findings align with Berger et al. [14], who found that banks maintaining liquidity during crises can mitigate risk.

To assess the validity and reliability of the instrumental variables in testing first-order autocorrelation (AR(1)) and second-order autocorrelation (AR(2)), Arellano and Bond [6] are employed. They stated that in the estimation of GMM, disturbance terms should exhibit first-order serial correlation but not second-order serial correlation. Therefore, the first-order regression coefficient AR(1) should be significant, while the second-order autocorrelation coefficient AR(2) should not be significant, as presented in Table 3 of the current study.

5 Conclusion and suggestions

Banks are one of the primary sources of financing for various businesses in Iran, highlighting the significant importance of bank stability, resilience, and risk reduction. Systemic banking risk in Iran stems from various factors, with one of the primary causes being economic policy uncertainty. In recent years, due to shocks such as oil price fluctuations, inflationary pressures, and currency rate shocks, economic policy uncertainty has increased. Examining its impact on systemic banking risk, alongside other influential factors (including balance sheet factors and economic variables), is of paramount importance. Therefore, in the current study, systemic banking risk was initially estimated for 17 listed banks using their balance sheet and non-balance sheet data over the period 2011-2021. Subsequently, the impact of Economic Policy Uncertainty (EPU), along with other control variables, on systemic banking risk was examined.

In the present study, we sought to answer the question of how Economic Policy Uncertainty (EPU) affects systemic risk in the banks listed on the Iran Stock Exchange?

Based on the results, Economic Policy Uncertainty (EPU) has a positive and significant effect at the 90% confidence level on systemic risk. Therefore, in the Iranian economy, various methods of increasing EPU can lead to an increase in systemic risk in banking. For instance, uncertainty and increased inflation expectations due to frequent changes in economic policies can discourage individuals from depositing money in banks. This reduction in deposits can increase systemic risk through the credit channel. Moreover, increased economic policy uncertainty can lead to crises and fluctuations in the stock market. This affects the stock performance of banks listed on the stock exchange and increases systemic risk in banking. Additionally, heightened economic policy uncertainty may result in the closure of various businesses, leading to an increase in loan defaults and consequently systemic risk in banks. Therefore, to reduce systemic risk in banking, it is crucial for economic conditions to be stable and for economic policy uncertainty to decrease.

Based on the results, banks such as Dey Bank, Ayandeh Bank, Parsian Bank, Pasargad Bank, Post Bank of Iran, Tejarat Bank, and The Melal Credit Institution have higher average systemic risk compared to the overall market systemic risk. On the other hand, banks like Saman Bank, Sarmayeh Bank, Saderat Bank, Melli Bank, Middle East Bank, Iran Zamin Bank, Sina Bank, Kar Afarin Bank, Tourism Bank, and Eghtesad Novin Bank have lower average systemic risk compared to the overall market systemic risk. Therefore, seven banks have above-average systemic risk, while ten banks have below-average systemic risk. Consequently, banks with higher systemic risk have a greater impact on the overall banking systemic risk. Therefore, to reduce systemic risk in the banking network, enhanced supervision, especially regarding loan issuance, is necessary for banks with higher systemic risk. This approach can potentially reduce the overall systemic risk in the banking network. Furthermore, among the control variables, inflation rate, total assets of banks, leverage ratio (debt to net assets), and gross loans as a percentage of total assets increase systemic risk. Therefore, the possibility of deposit withdrawal for various reasons such as negative real interest rates, lack of asset diversification by banks, and inefficiency in bank management due to reasons such as having too many branches, bank run risk, and mismatch between deposits and loans can increase systemic risk. Among the control variables, nominal GDP growth, average asset return (ROA), interest income to operating income ratio, loan loss provisions to gross loan value ratio, and cash to total deposits and liabilities ratio reduce systemic risk. Therefore, economic growth and increased activity in various industries, proportional investment in diverse assets with varied returns, reducing loan default risk, and ensuring adequate reserves to cope with loan default crises can reduce systemic banking risk.

Based on the results, banks facing higher levels of loan defaults exhibited greater systemic risk. Therefore, it is recommended to exercise greater caution in lending practices and ensure proper commitments for loan repayment, particularly for large loans to diverse individuals rather than specific groups. This approach can mitigate systemic banking risk by reducing the likelihood of loan defaults. Moreover, directing loans towards productive and industrial activities aimed at economic prosperity can further reduce systemic risk. To decrease systemic risk, it is essential to reduce economic policy uncertainty. This requires minimizing economic shocks and uncertainties, particularly lowering inflation expectations, and maintaining consistency in government policies in the short term to enhance public confidence in economic conditions. Furthermore, during periods of increased economic policy uncertainty, it is crucial to maintain an appropriate balance between deposit collection and lending levels. Particularly, effective supervision during lending activities is essential. By adhering to appropriate leverage ratios, systemic banking risk can be reduced. Moreover, adequate oversight by regulatory authorities over banks is necessary, especially imposing strict restrictions on banks that have faced defaults and multiple violations in recent years regarding their lending and deposit-taking activities. This approach aims to decrease systemic risk, fostering greater discipline among all banks to avoid regulatory constraints.

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