# An Index of Financial Stress for Economic Growth Analysis Using Macro Data: Case of a Developing Economy

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## Abstract

A major objective of a financial stress index (FSI) is to help policymakers determine whether financial stress is high enough to be a serious concern. According to the literature each variable in the FSI has to reflect prices or yields on financial markets, on the grounds that market prices and yields embody the largest amount of information and are the quickest to reflect changes in financial conditions. But this criterion of variables often is not available in developing countries with underdeveloped financial markets. This paper presents a new index of financial stress which is constructed by macro data from different financial markets (including banking sector and also housing, foreign exchange and stock markets). The proposed approach has been applied to the Iranian economy based on the available quarterly time series, covering the period 1994(1)–2008(2). The paper explains how the selected components capture key aspects of financial stress. The regression of cyclical components technique and weighting by coefficients of determination is used as a weighting scheme. The results of the estimated growth model show that the constructed FSI provides valuable information about economic growth volatilities.

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## 1. Introduction

In most general terms, financial stress can be thought of as an interruption to the normal functioning of financial markets. Economists tend to associate certain key phenomena with financial stress. The relative importance of these phenomena may differ from one episode of financial stress to another. However, every episode seems to involve at least one of the phenomena, and often all of them. Increased uncertainty about fundamental value of assets, increased uncertainty about behavior of the other investors, increased asymmetry of information, decreased willingness to hold risky assets (flight to quality), decreased willingness to hold illiquid assets (flight to liquidity), are the key features of financial stress[2]. In constructing of the financial stress index (FSI) all the above key features should be captured. Stress is defined as the force exerted on economic agents by uncertainty and changing expectations of loss in financial markets and institutions. It is a continuous variable with a spectrum of values, where extreme values are called financial crises.

There are two important elements in constructing an FSI: the choice of variables and the weighting scheme. Information about financial stress is extracted from a wide array of financial variables using several techniques, including factor analysis, econometric benchmarking, and generalized autoregressive conditional heteroscedasticity (GARCH) modeling. The choice of how to combine the variables (the weighting method) is perhaps the most difficult aspect of constructing an FSI. The difficulty in choosing weights lies in the lack of a reference series upon which different, meaningful weights can be derived and tested. Various weighting techniques are considered, including: factor analysis, credit aggregate-based weights, and variance equal weights. In all cases, the indexes are rebased such that they range in value from 0 (low stress) to 100 (high stress).

According to the empirical literature such as Illing and Liu (2003, 2006), Hanschele and Monnin (2005), Hakkio and Keeton (2009), Cardarelli et al (2009), each variable in the FSI has to reflect prices or yields on financial markets, on the grounds that market prices and yields embody the largest amount of information and are the quickest to reflect changes in financial conditions. But this criterion of variables often is not available in developing countries with underdeveloped financial markets. This paper presents a new index of financial stress which is constructed by macro data from different financial markets. The paper explains how the selected components capture key aspects of financial stress. The paper also

[2] For more details about empirical definitions of a financial crisis see: Frankel and Rose (1996), Saches, Tornell and Vellasco (1996), Radelet and Sachs (1998), Ferreti, and Razin (1998), Barro (2001), Edison (2000), Bussiere and Fratzschere (2002), Mishkin (2000a,b)

shows that the constructed FSI provides valuable information about economic growth volatilities.

## 2. Selecting variables for the proposed FSI

Table 1 summarizes the selected variables from different financial markets such as banking sector, foreign exchange market, stock market, and housing market.

**Table 1: Variables included in the financial stress index**

| Financial Markets | | Variables and Stress Evaluation |
|---|---|---|
| Banking Sector | Assets and Liabilities | Increasing the M0 to M1 ratio from trend |
| | | Increasing the M1to M2 ratio from trend |
| | | Increasing the short term deposits to long run deposits ratio from trend |
| | | Non-demand deposits instability[3] |
| | | Decreasing the non-public sector deposits to GDP from trend |
| | | Deviation of banks claims on non- public sector to GDP from trend |
| | | Default on the exchanged securities |
| | | Growth of the loans to deposits ratio |
| | | Increasing the Central Bank claims on banks to monetary base from trend |
| | Public Policy | Negative real interest rate (weighted average of expected returns of banking deposits) |
| | | Unexpected money growth |
| | | Inflation tax |
| | | Structure of banking system (No of private banks to the total) |
| Foreign Exchange Market | | High exchange rate premium (Deviation of official exchange rate from free market rate) |
| | | Real exchange rate[4] volatility |
| Housing Market | | Housing price volatility |
| Stock Market | | Stock price volatility |

## 3. Data

The data involve available quarterly time series for the Iranian economy, as an oil exporting-developing economy, covering the period 1994(1) – 2008(2).

## 4. Stress index for different financial markets

### 4.1 Banking Sector

In constructing the banking sector stress index, each of 13 selected variables from banking sector (Table 1) is evaluated as a stress index and scored between 0 (low stress) to 100 (high stress) by using the Mini-Max approach. Then the regression of

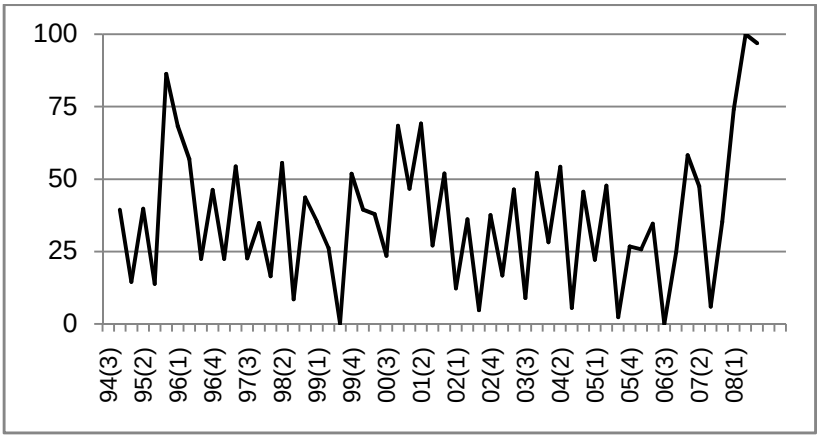
[3] Defines as: 100- coefficient of long run deposits changes (cv), where cv is the standard deviation of deposits to its moving average, multiplied by 100.

[4] Real exchange rate defines as:

$$RER = \frac{ER \cdot P_{OECD}}{P_{GDP}}$$

cyclical components technique and weighting by coefficients of determination[5] (Holmes, 1986) is used as a weighting scheme. It seems reasonable to assume that weighting index components by coefficients of determination will maximize accuracy of economic growth analysis. Thus, correlograms were computed to initially identify components to be considered for inclusion in the stress index. Then, Holmes' empirical method of weighting components was adopted and weights were assigned to components based upon the coefficient of determination calculated between each component and the economic growth volatility component. Figure 1 illustrates the stress index of the banking sector.

**Figure 1: The Stress Index of Banking Sector (1994:3–2008:2)**
**(0 = low stress 100 = high stress)**




### 4.2 Foreign Exchange Market

Figure 2 illustrates the stress index of the foreign exchange market which is included exchange rate premium and real exchange rate volatility. The generalized autoregressive conditional heteroscedasticity (GARCH) technique has been used for modeling of the volatility and then the regression of cyclical components approach, as the weighting scheme, applied for the composite stress index of foreign exchange market.

### 4.3 Stock Exchange Market

Figure 3 illustrates the stress index of the stock exchange market which is defined as the stock price volatility based on the GARCH technique.

### 4.4 Housing Market

Figure 4 illustrates the stress index of the housing market which is defined as the housing price volatility based on the GARCH technique.

[5] A measure of goodness of fit of the relationship between the dependent and independent variables in a regression analysis.

**Figure 2: The Stress Index of Foreign Exchange Market (1994:3–2008:4)**
**(0 = low stress  100 = high stress)**

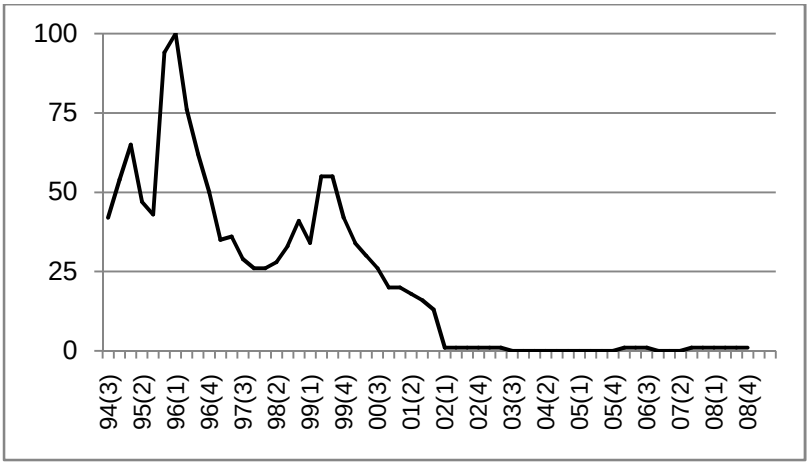



**Figure 3: The Stress Index of Stock Exchange Market (1994:3–2008:4)**
**(0 = low stress  100 = high stress)**

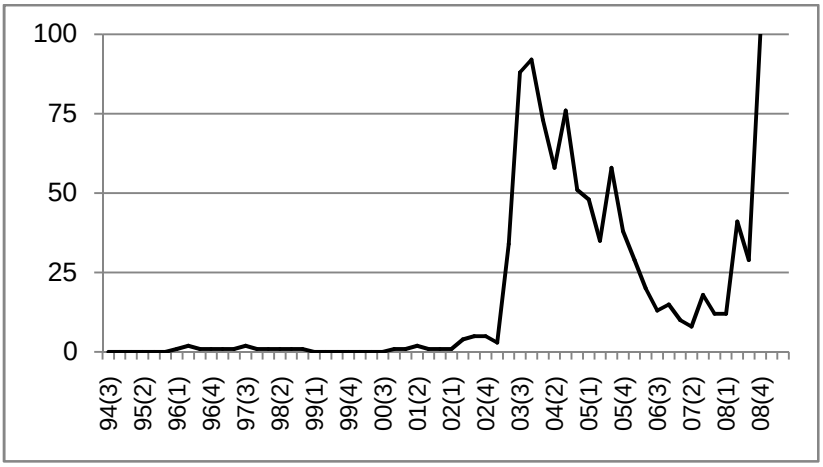
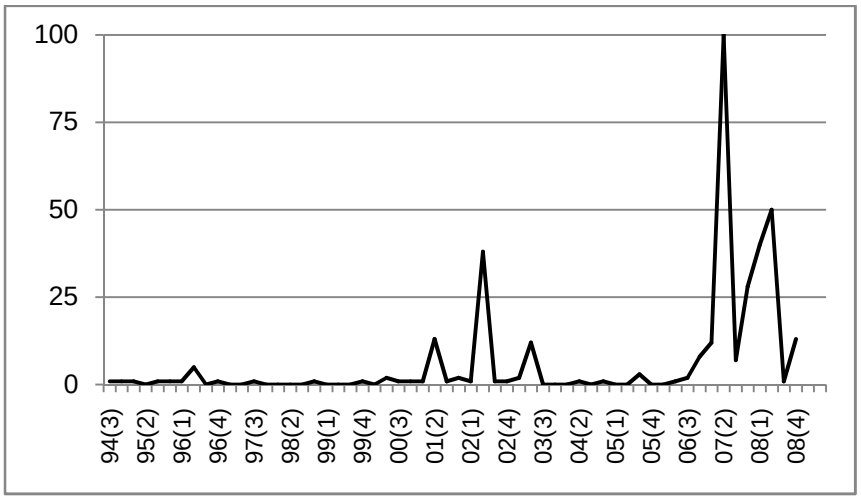


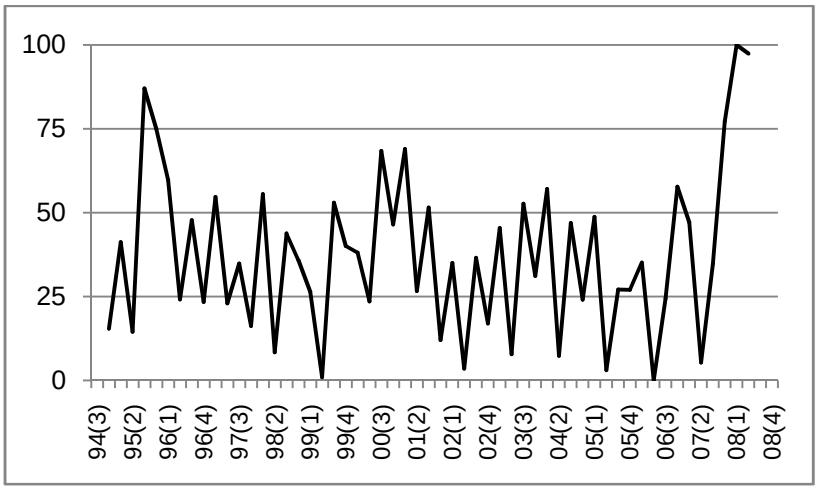

**Figure 4: The Stress Index of Housing Market (1994:3–2008:4)**
**(0 = low stress  100 = high stress)**



## 5. The Composite Financial Stress Index (FSI)

Figure 5 illustrates the composite stress index of the financial markets which is included 5 stress indices of different financial markets and developed by the regression of cyclical components approach as the weighting scheme.

**Figure 5: The Composite Financial Stress Index (1994:3–2008:2)**
**(0 = low stress 100 = high stress)**




According to the results, Table 2 also presents the relative importance of selected variables in the composite FSI. Based on the computed weights of variables, changes of outstanding deposits of non-public sector to GDP (19.5%), currency and notes to M1 (15.5%), banks claims on non- public sector to GDP (13.5%), inflation tax (13.5%), and M1 to M2 ratio (11.25%) are important variables in the FSI.

A major objective of a financial stress index (FSI) is to help policymakers determine whether financial stress is high enough to be a serious concern. Table 3 indicates the financial crisis periods in the economy of Iran based on constructed FSI during the 1994-2008.

**Table 2: Relative Importance of the Selected Variables in the Composite FSI**

| Financial Markets | Variables | Relative Importance |
|---|---|---|
| Banking Sector | M0 to M1 ratio | 15.52 |
| | M1to M2 ratio | 11.25 |
| | Short term deposits to long run deposits | 3.75 |
| | Non-demand deposits instability | 1.5 |
| | Non-public sector deposits to GDP | 19.5 |
| | Banks claims on non- public sector to GDP | 13.5 |
| | Default on the exchanged securities | 4.5 |
| | Loans to deposits ratio | 1.5 |
| | Central bank claims on banks to monetary base | 3.75 |
| | Real interest rate (expected returns of banking deposits) | 0.38 |
| | Unexpected money growth | 0.53 |
| | Inflation tax | 13.5 |
| | Structure of banking system | 5.25 |
| Foreign Exchange Market | Exchange rate premium | 1.37 |
| | Real exchange rate volatility | 1.37 |
| Housing Market | Housing price volatility | 1.57 |
| Stock Market | Stock price volatility | 1.26 |
| | **Total** | 100 |

**Table 3: Financial Crisis Periods**
**(Based on the measurement of financial stress indices)**

| Financial Crisis (Composite FSI) | Stock Market | Foreign Exchange Market | Housing Market | Banking Sector |
|---|---|---|---|---|
| 1995:3-1995:4 | 2003:3-2003:4 | 1995:4 – 1996:2 | 2007:2 | 1995:3 |
| 2007:4 – 2008:2 | 2004:3 | | 2008:2 | 2007:4 -2008:2 |
| | 2008:4 | | | |

## 6. Economic Growth Analysis

In the last section of the paper, attempts are made to investigate the impact of financial stress on the Iranian economic growth using an econometric model. According to the contribution of Mankiw, Romer and Well (1992) to the empirics of economic growth, the growth equation is derived as follows:

Let production function is:

$$Y = A_0(A_K K)^{\alpha}(A_H H)^{\beta}\ (A_L L)^{1-\alpha-\beta} \quad (1)$$

The notations are standard: $Y$ is output, $K$ capital, $L$ labor, $H$ is the stock of human capital, $A_0$ is the total factor productivity (included macroeconomics and institutions environment), and $A_K$, $A_H$, $A_L$ are productivity level of physical capital, human

capital and labor, respectively. By definition of *A* as the level of technology, equation (1) can be written as equation (3). *L* and *A* are assumed to grow exogenously at rates *n* and *g*. x is the vector of policy variables and other factors that impact to productivity and the level of knowledge.

$$A = A_L\left(A_0 A_K^{\alpha} A_H^{\beta}\right)^{\frac{1}{1-\alpha-\beta}} \quad (2)$$

$$Y = K^{\alpha} H^{\beta} (AL)^{1-\alpha-\beta} \quad (3)$$

$$L(t) = L(0)e^{nt} \quad (4)$$

$$A(t) = A(0)e^{(gt+X\theta)} \quad (5)$$

Let $S_K$ and $S_h$ be the fractions of income invested in physical and human capitals. The evolution of the economy is determined by:

$$\dot{k} = s_k\, y - (n+g+\pm)\, k \quad (6)$$

$$\dot{h} = s_h\, y - (n+g+\pm)\, h \quad (7)$$

Where *k = K/AL, h = H/AL and y = Y/AL* are quantities per effective unit of labor. It is assumed that human capital depreciates at the same rate as physical capital and $\alpha+\beta<1$. Equations (6), (7) imply that economy converges to a steady state defined by:

$$k^* = \left[\frac{S_K^{1-\beta} S_h^{\beta}}{n+g+\sigma}\right]^{\frac{1}{1-\alpha-\beta}} \quad (8)$$

$$h^* = \left[\frac{S_k^{\alpha} S_h^{1-\alpha}}{n+g+\sigma}\right]^{\frac{1}{1-\alpha-\beta}}$$

Substituting (8) into the production function and taking logs gives an equation for income per capita where $\gamma=\alpha+\beta$:

$$Ln\left(\frac{Y}{L}\right) = Ln\, A_0 + g\, t + x\theta - \left[\frac{\gamma}{1-\gamma}\right] Ln(n+g+\sigma) + \left[\frac{\alpha}{1-\gamma}\right] LnS_k + \left[\frac{\beta}{1-\gamma}\right] LnS_h$$

An empirical version of this growth equation, with emphasis on main features of the Iranian economy (the dominant roles of government and oil revenues) is as follows:

$$y_t = c_1 + c_2\, I_t + c_3\, H_t + c_4\, G_t + c_5\, G^2{}_t + c_6\, OIL_t + c_7\, FSI_t + u_t$$

Where y represents the growth of real GDP, I the private investment to GDP as a proxy for the rate of physical capital accumulation ($S_k$), H the average years of education of labor force multiply to employment as a proxy for the rate of human capital accumulation ($S_h$), Oil the oil and gas revenues deflated by OECD price

index, G the government expenditure to GDP as an index for the government size, $G^2$ the quadratic form of G for testing the invert U shaped relation between government size and economic growth, and FSI the financial stress index (included composite FSI and financial stress index for banking and non-banking sectors)

According to the modern econometric methods, prior to any analysis, it is imperative to test the stationary and integration order of variables. The stationary situations of all the variables are presented in Table 4.

**Table 4: ADF Unit Root Test of the Model Variables**

| MODEL VARIABLES | | Critical Value | | | ADF TEST | |
|---|---|---|---|---|---|---|
| | | 1% | 5% | 10% | | |
| **y** | Economic growth | -3.53 | -2.91 | -2.59 | -35.9 | I(0) |
| **FSI** | Composite financial stress index | -3.56 | -2.92 | -2.59 | -3.63 | I(0) |
| $\mathbf{FSI_{Bank}}$ | financial stress index for banking sector | -3.56 | -2.92 | -2.59 | -3.83 | I(1) |
| $\mathbf{FSI_{Other}}$ | financial stress index for non-banking sector (included stock, exchange and housing markets) | -3.53 | -2.91 | -2.59 | -9.24 | I(1) |
| **G** | Gov. expenditure to GDP | -3.53 | -2.91 | -2.59 | -16.8 | I(1) |
| **I** | Private investment to GDP | -3.53 | -2.91 | -2.59 | -4.88 | I(1) |
| **OIL** | Growth of oil revenues | -3.59 | -2.93 | -2.59 | -4.09 | I(0) |
| **H** | Human capital index | -3.53 | -2.91 | -2.59 | -8.93 | I(1) |

## 7. Estimation Results and Conclusions

For dynamic analysis of impacts of financial stress on economic growth, the model is estimated by general to specific approach[6]. General-to-specific (Gets) model selection is a central feature of what is often referred to as the 'LSE' methodological approach to econometric modeling. It involves the formulation of a 'general' unrestricted model that is congruent with the data and the application of a 'testing down' process, eliminating variables with coefficients that are not statistically significant, leading to a simpler 'specific' congruent model that encompasses rival models. Table 5 illustrates the estimation results of two economic growth models, which is included the short and long run estimated coefficients with statistical tests. The appropriate unit root test was applied for cointegration testing by calculating the t values based on the estimated dynamic models. The critical values are given in Banerjee, Dolado, and Mestre (1992).

According to the results, the coefficients of oil revenues, human capital index, private investment to GDP, and government expenditure to GDP are positive and

[6] See Hendry (1994, 1995), Lutkepol (2007)

significant. The relationship between economic growth and the size of government is in adverse U shape. The financial stress, in form of differentiated indices for banking and non-banking financial markets (Model 1) and also a composite index (Model 2), has a negative effect on economic growth. Because of bank based financial system of many developing economies, the banking sector stress is expected to have a greater negative impact on growth.

Finally, macro stress-testing raises a number of important policy questions that would deserve further attention. Integrated by models of early-warning indicators and macroeconomic forecasts as inputs, stress-tests could represent a useful tool to enhance macroprudential policies.

Furthermore, macro stress-testing may be useful to address monetary policy trade-offs, incorporating financial stability considerations into monetary policy decision-making. For example, using a Taylor rule allows calibrating the possible trade-off between the pursuits of monetary and financial stability in case of an adverse supply shock.

**Table 5: Estimation Results**

| Variables | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | **Short run** | **Long run** | **Short run** | **Long run** |
| **I** | 12.3 | 15.4 | 5.06 | 13.1 |
| **H** | 0.064 | 0.008 | 0.018 | 0.06 |
| **G** | 451.3 | 448.8 | 76.8 | 77.9 |
| **$G^2$** | -1155 | -1302.6 | -292.7 | -236.1 |
| **OIL** | 7.84 | 9.15 | 8.32 | 10.3 |
| **FSI** | - | - | -0.16 | -0.17 |
| **$FSI_{bank}$** | -0.037 | -0.032 | - | - |
| **$FSI_{other}$** | -0.022 | -0.020 | - | - |
| **$R^2$** | 0.99 | | 0.99 | |
| **TEST** | **Model 1** | | **Model 2** | |
| | Statistics | *P Value* | Statistics | *P Value* |
| White | F = 0.95<br>$X^2$=30.1 | 0.56<br>0.45 | F = 0.86<br>$X^2$=34.5 | 0.64<br>0.49 |
| Breusch_Godfrey | F = 0.020<br>$X^2$=0.102 | 0.97<br>0.94 | F = 0.24<br>$X^2$=0.91 | 0.79<br>0.63 |
| Jarque_bera | $X^2$=0.46 | 0.79 | $X^2$=1.61 | 0.45 |
| Ramsey | F = 1.96<br>$X^2$=2.76 | 0.17<br>0.096 | F = 0.43<br>$X^2$=0.79 | 0.51<br>0.37 |
| $t = \left\| \frac{\sum_{i=1}^{p} \hat{\alpha}_i - 1}{\sum_{i=1}^{p} S_{\hat{\alpha}_i}} \right\|$ | -11.05 | | -4.2 | |
| Banerjee, Dolado, and Mestre Critical values (5%) | -3.82 | | -3.82 | |

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