The Institute of Financial Economics Financial Stress Index (IFEFSI) for Lebanon[1]

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Abstract

The aim of this paper is to construct the first Financial Stress Index for Lebanon, dubbed the IFEFSI (Institute of Financial Economics Financial Stress Index). This is a broad coincident composite index that includes three different market segments; the banking sector, the equities market, and the foreign exchange and debt markets. It is constructed as a continuous real-time measure that quantifies the level of systemic stress by measuring latent conditions. As a metric for financial conditions, the IFEFSI should provide valuable information to macroprudential regulators whose aim is to maintain a smooth and resilient financial system. By using it as a tool to help monitor, identify, and address any potential crisis, they are better equipped to maintain financial and economic stability in Lebanon.

Keywords: Financial Stress Indicator, Financial Crisis, Lebanon, Economic Policy.

JEL: G01, G18, G20, E44, E58

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1. Introduction

Although monitoring the stability of the financial markets and regulating the sector has been ongoing for decades, in general, financial shocks' effect on the economy had been underestimated in the period before the 2008 crisis. Consequently, financial markets were barely represented in macroeconomic models (Borio, 2014). Financial stress[2] analyses have since gained significant attention; Oet et al. (2011) note that while no series representing financial stress in the US existed in 2008, 12 alternative series were available by 2010. Numerous researchers have explored the ways and the extent to which financial stress is related to—in most cases precedes—economic contractions (see, e.g., Basu and Bundick, 2017; Bonciani and Van Roye, 2016; Cardarelli et al., 2011; Cevik et al., 2016; Christiano et al., 2015; Creel et al., 2015; Kliesen et al., 2012). Besides producing negative effects on economic growth, evidence was found that not only are recessions substantially longer when there is simultaneous financial stress (Reinhart and Rogoff, 2009), but the magnitude of output losses is larger compared to recessions that do not coincide with financial market stress episodes (Claessens et al., 2012; Gupta and Miniane, 2009; Jorda et al., 2013; Kannan, 2012).

Adverse financial conditions can potentially be transmitted to the whole economy via multiple channels. More importantly, even small financial shocks can even be amplified and lead to a large deterioration in economic conditions, a process known as financial accelerator (Bernanke et al., 1994). There is, thus, widespread consensus about the importance of understanding the complex interconnectedness among a country's financial institutions and markets, the different channels for the propagation of any financial shock, and their role in magnifying (or mitigating) such financial shocks. Consequently, much effort has been devoted to constructing models for systemic[3] events that treat crises as system-wide events and can have early detection capabilities for financial stress episodes in a country. The backbone of these models is a financial stress index, which is important for several reasons. First, it provides a quantitative scale to assess the intensity of the fragility of the financial sector at any point in time. Unlike binary measures, with a continuous index, one can compare the severity of different crises. Second, it helps identify the source or origin of the stress by examining the contribution of each underlying indicator to the overall stress level. Third, since any stress in the financial markets has adverse effects on the health of the economy (Cevik et al., 2013), these indices can help avoid or mitigate these effects if the proper tools are employed during the 'build-up' stage of a crisis. Finally, the index can be used by policymakers to gauge and evaluate the performance of different policy measures, by comparing the stress levels pre- and post- policy implementation.

Since 2003, when the first country-level financial stress index (FSI hereafter) was constructed for Canada (Illing and Liu, 2003), many such indexes were constructed, especially for developed countries. A few emerging countries have also constructed their own FSIs. Such methods-based indexes are preferable to expert-based approaches for several reasons. By

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[2] Note that in this context, financial stress is defined as a period during which one or more financial markets are simultaneously in turmoil (Duprey et al., 2017). The literature also mentions at least two underlying stress features: increase in uncertainty and changing expectations (Cevik et al., 2016).

[3] According to Kliesen et al. (2012), systemic risk is defined as "the chance that financial instability will lead to macroeconomic instability."

definition, "the FSI captures the contemporaneous level of stress and is not expected to have strong predictive power for future stresses or crises" (Illing and Liu, 2006).

The main contribution of this paper is the construction of the first Financial Stress Index for Lebanon named the Institute of Financial Economics Financial Stress Index (IFEFSI). This is a broad index that includes three different market segments; the banking sector, the equities market, and the foreign exchange and debt markets. It is constructed as a continuous contemporaneous measure that quantifies the level of systemic stress. Due to the comprehensiveness of our index, we are able to identify events that are truly systemic, and not simply due to instability in a single market segment. To date, Lebanon has relied on an expert-based approach for identifying financial stress episodes, but this method is plagued with weaknesses. For example, it is widely believed that experts experience greater stress during events that are the most frightening but not necessarily the most systematically stressful (Oet et al., 2011). What is needed is a reproducible method that distinguishes between periods of market tranquility and periods of stress, which is what the IFEFSI provides.

Ten different indicators representing the three financial sectors (banking, equity, foreign exchange and debt) were deemed relevant and hence were included in the construction of the index. These variables were standardized and then aggregated using two methods (equal weighting and principal components analysis) to obtain the final IFEFSI.

In the IMF's Staff Concluding Statement of the 2018 Article IV Mission, it is stressed that financial stability risks in Lebanon should be contained. In that context, the IFEFSI should provide valuable accurate and timely information to macroprudential regulators whose aim is to maintain a smooth and resilient financial system. By using it as a tool to help monitor, identify, and address any potential crisis, they are better equipped to maintain financial and economic stability. The IFEFSI will be used in future work to help identify leading indicators of financial stress for Lebanon, so that policymakers can focus on attempting to avoid increases in financial stress, rather than reacting after stress levels increase. This also provides valuable time to select, fine-tune, and implement the most appropriate tools.

The remainder of the paper proceeds as follows. Section 2 presents a review of the relevant literature. Section 3 provides an exposition of the data and the indicators selected for constructing the IFEFSI. Next, the methodology followed is presented in section 4, followed by a discussion of the resulting IFEFSI in Section 5. Finally, we offer some concluding remarks in Section 6.

2. LITERATURE REVIEW

After a series of global financial crises in the 80s and 90s, policymakers started exploring indicators that are capable of predicting financial stress events. Historically, experts have relied on basic methods, mainly referred to as early warning indicators, to gauge financial instability. The probability of a banking crisis, for example, has been shown to be greater with low economic growth, capital equity, and reserve coverage of risky loans ratios, in addition to high inflation rates (Demirguc-Kunt and Detragiache, 1998; Gonzalez-Hermosillo, 1999). Another set of indicators, such as international reserves and real exchange rates, have been found to be useful in capturing currency crisis incidents (Frankel and Rose, 1996; Kaminsky et al., 1998). In other cases, some indicators have been used to detect credit risk, such as interest rate spreads

between corporate and Treasury bonds (Duca, 1999). Studies have also shown that sharp declines in equity prices have negative effects on stock market stability leading to an equity crisis (Patel and Sarkar, 1998). Despite the variety of financial sectors or markets analyzed in the context of financial vulnerability, a common overall feature among initial research has been the dependence on stand-alone variables or indicators without considering the interrelationship and interdependence among various financial sectors.

Subsequently, experts began to introduce indexes which combine a group of variables from the same or different markets to detect financial shocks. The benefit of these indexes is that they create value measurements for latent conditions in the economic and financial markets by applying mathematical and statistical methodologies to track both systematic and unsystematic risks. Earlier indexes focus mostly on one market such as the monetary market (Batini and Turnbull, 2002; Freedman, 1994), the equity market (Patel and Sarkar, 1998), or others. Later, economists started to take into account additional financial and non-financial variables to develop a new type of index: the Financial Conditions Index (FCI) (Bordo et al. 2002). Examples of FCIs are the Bloomberg Financial Conditions Index (Rosenberg, 2017) and the Federal Reserve Bank of Chicago National Financial Conditions Index (Brave and Butters, 2011) amongst many others (Angelopoulou et al., 2014; Balcilar et al., 2016; Gauthier et al., 2003; Guichard and Turner, 2008; Hatzius et al., 2010; Lack, 2003; Montagnoli and Napolitano, 2005; Osorio et al., 2011).

A closely related index to the FCI is the financial stress index (FSI) that has also been developed to identify episodes of stress. While the FCI and FSI are very similar in their purpose and construction mechanism, FCIs use prices, quantities, and economic indicators such as GDP in their composition whereas FSIs rely primarily on prices of variables (Kliesen et al., 2012). FSIs are associated to other related indexes, like the index of financial safety (Jia and Li, 2015; Matkovskyy et al., 2016) and the index of financial fragility (Bagliano and Morana, 2014). Moreover, the FSI is considered to be the mirror image of the financial stability index (Lee et al., 2013; Morales and Estrada, 2010).

The first FSI can be traced back to Illing and Liu (2003), who construct an FSI to examine systemic risk in Canada. Their FSI is composed of variables from the bank, foreign exchange, bond, and equity markets. Indicators are then aggregated together into one index using various weighting methodologies, namely factor analysis, credit aggregate-based weights, variance equal weights, and variable transformations based on their sample cumulative distribution functions. Their FSI has since been used in several empirical studies for Canada (Misina and Tkacz, 2008). Building upon Illing and Liu's (2003, 2006) work, several FSIs have been created to date distinguished by the countries and regions analyzed, variables utilized, and construction techniques applied (see Table A.1).

The majority of papers discussing FSIs and their applications have focused on developed countries. A seminal paper by the IMF (Cardarelli et al., 2009) constructs an FSI for 17 developed countries concurrently by applying the variance weighted approach to aggregate indicators of exchange rate volatility, corporate bond spreads, equity returns, equity volatility, inverted term spread, and TED spread. An abundant amount of research has been dedicated to the US financial market, especially following the 2008 financial crisis. The Federal Reserve

Bank of Kansas City Financial Stress Index (Hakkio and Keeton, 2009), the Federal Reserve Bank of St. Louis Financial Stress index (Kliesen and Smith, 2010), and the Federal Reserve Bank of Cleveland Financial Stress Index (Oet et al., 2011) are some examples of US FSIs. Similarly to the U.S., country-specific FSIs have been developed for, among others, Denmark (Hansen, 2006), Hong Kong (Yiu et al., 2010), Sweden (Sandahl et al., 2011), Greece (Louzis and Vouldis, 2013), and France (Aboura and Roye, 2017). These FSIs incorporate data from the equity and bond markets similar to the US FSIs; however, the presence of foreign exchange indicators is more evident. In some cases, the FSI concentrates predominantly on bank information, such as the FSI for Switzerland (Hanschel and Monnin, 2005), which includes data from perceptions on banking conditions, total interbank deposits, and number of bank branches.

Other studies create an FSI for multiple developed countries enabling analysis across economies of the same region. For the members of the Euro area, Hollo et al. (2012) construct an FSI called the Composite Indicator of Systemic Stress (CISS) with a special methodological feature that combines its sub-indexes according to their time-varying cross-correlations; thus, the CISS gives higher weights to situations where stress occurs in different markets of an economy simultaneously. Furthermore, the FSI methodology of Cardarelli et al. (2009) was later adopted by many authors who examined multiple developed countries, such as members of the OECD, G7, and G5 countries (Christensen and Li, 2014; Magkonis and Tsopanakis, 2014, 2016; Melvin and Taylor, 2009; Slingenberg and De Haan, 2011).

Balakrishnan et al.'s (2009, 2011) influential work, propose a framework for developing FSIs for multiple emerging countries. Their index, known as the Emerging Markets FSI (EM-FSI), adjusts the FSI proposed by the IMF (Cardarelli et al., 2009) for developed economies to account for specific conditions for emerging economies. This is done by taking into consideration five components: the banking sector beta, stock market returns, time-varying stock market return volatility, sovereign debt spreads, and an exchange market pressure index. El-Shal (2012) examines the spillover effects of the global financial crisis on the Egyptian economy by adopting the EM-FSI methodology to construct an FSI for Egypt. Cevik et al. (2013) modify and extend the EM-FSI to apply it for Bulgaria, the Czech Republic, Hungary, Poland, and Russia. Following a parallel approach, Cevik et al. (2016), Dahalan et al. (2016), and Tng et al. (2012), create FSIs for several Asian countries. As a leading emerging economy, Turkey has received a significant portion of the studies on the topic. The Central Bank of Turkey has developed a national FSI (Financial Stability Report of Central Bank of Turkey, 2009). Moreover, several researchers such as Cevik et al. (2013) and Ekinci (2013) have created FSIs for Turkey by including indicators distinctive to the country's economy.

Some studies, on the other hand, have constructed FSIs for a mix of developed, developing, and emerging countries. One example is the study by Lo Duca and Peltonen (2013) who create the same FSI for 28 emerging and advanced countries, to identify systemic stress and assess its joint occurrence with economic downturns across their selected sample. Another example is Zigraiova and Jakubik (2015) who apply cross-country comparison of financial stress by constructing an FSI for 14 developing and advanced economies, including members of the European Union and OECD, in addition to others such as Argentina, Russia, and Thailand. Similarly, Duprey et al. (2017) construct a country-specific FSI for 27 European Union countries, and use it to build a monthly chronology of EU systemic financial stress episodes.

In spite of the increased interest in investigating financial shocks through FSIs globally, there is still an ongoing gap in the literature for developing and emerging countries, especially in the Middle East, that this study aims to fill.

3. Data and Description of Indicators

The construction of an IFEFSI requires first the identification of the relevant financial sectors to be included. Next, one or more indicators within each sector should be selected. These are usually indicators that reflect any actions of stress, panic, uncertainty and insecurity by economic agents and the regulators' response. In effect, chosen indicators represent simultaneously economic agents' behaviors, monetary authority's policies, and policy makers' decisions in each particular period. Finally, the specific indicators are normalized, and then aggregated into an index using an appropriate statistical technique.

In our work, we follow the methodology of Balakrishnan et al. (2009, 2011), but extend it to better represent a developing country such as Lebanon. Thus, the first Lebanese Stress Index IFEFSI is a tailored stress index that includes the specificities of the Lebanese financial sector. It is composed of three main sectors: (i) the banking sector, (ii) the equity market, and (iii) the foreign exchange and debt markets. Foreign exchange and debt markets are considered together in one sector because of their tight correlation in Lebanon.

Although data are available starting in 1990 (end of the civil war), we have chosen to consider the period January 1998 to January 2018. That way we would have avoided the turbulent reconstruction period, and the problem of accounting for different exchange rate regimes.[4]

The BLOM index (BMI) and six[5] listed banks' returns are given on a daily basis by DataStream and Beirut Stock Exchange. They are then converted to a monthly frequency (last day of the month). US data needed to construct the EMPI, foreign reserves, Fed Fund and broad money are sourced from the St Louis Fed Fred economic data database. All remaining variables are taken from the BDL website on a monthly basis.

All variables are included in growth rate format or percentage change format, except for the interest rates. Given that indicators usually have different measurement units, normalization is required prior to aggregation (OECD, 2008). Each series is thus standardized by subtracting the mean and dividing by its standard deviation.

3.1 Banking Sector

For many years, the Lebanese banking sector has been a stable and profitable sector. It has contributed to an average of 6% of GDP growth and has projected a strong sense of confidence and security by its resilience to surrounding geopolitical conflicts, its innovation in products and services, and by being technologically up-to-date and operating in alignment with international standards (IMF, 2017). Although relatively solid, Lebanese banks remain highly

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[4] At the end of 1992, the Lebanese central bank adopted a *stabilization policy* based on the exchange rate regime but this latter was officially applicable in 1997 where the US dollar was defined to be fixed and equal to 1,500-1,515 Lebanese Pound (± 0.5% change). It took about one year for the Lebanese pound to be totally stabilized.

[5] AUDI, Bank of Beirut, BEMO, BLC, BLOM, and Byblos.

exposed to stress and even to severe crises due to the following reasons: (i) the secondary market in government debt and the Central Bank of Lebanon (BDL) certificates of deposit are illiquid, (ii) deposits are highly concentrated and dollarized, (iii) banks are the main source of investment in absence of corporate bonds, and (iv) they hold more than fifty percent of the government total debt, similarly to African countries (IMF, 2017). According to Christensen (2005), although private banks benefit from returns provided from government debt, accumulating more domestic debt might have a crowding out effect on the economy by decreasing overall bank loans. Under these circumstances, any uncertainty in the market can easily lead to depositors' runs or "flight to safety[6]" thus quickly spreading ménages panics to the whole banking system (see Gorton, 2009). Consequently, selecting appropriate indicators for this sector must be carefully done.

3.1.1 Inverted Yield (INVY)
The inverted yield curve measures the difference between the T-bills short term (ST) yield and their long term (LT) yield. It is considered to be one of the best leading indicators that can predict economic recessions in the upcoming months (Chinn and Kucko, 2015). Normally, a higher yield corresponds to a higher inflation rate (that normally accompanies economic growth), while a lower LT yield signals deflation and potentially a recession.

Besides predicting an economy's recession, the inverted yield signals tightened credits (Death of Credit), thus exposing banks to higher risks. Many economists (see Borio et al., 2017; Buch et al., 2014; Busch and Memmel, 2017; De Nicolo et al., 2010; Ioannidou et al., 2014; Jimenez et al., 2014; Maddaloni and Peydró, 2011; Paligorova and Santos, 2017; inter alia) have studied the consequences of yield curve changes in the US and European countries. There is widespread consensus that since the main role of a bank is to transform maturity from short term liabilities (deposit) to long term assets (loans), positive spreads expose banks to higher credit risk in order to counteract for decreasing profits.

In constructing the IFEFSI, the inverted yield that measures the sovereign risk, is taken as a proxy of banks' credit risks. INVY is conventionally taken as the difference between 1 year or 2-year T-bills and the 10-year T-bonds. Since in Lebanon the long term T-bonds (more than 2 years) are very rare and almost nonexistent, 3 months T-bills and 24 months T-bills are taken to represent respectively the short term and the long term T-bills.

3.1.2 Lebanese TED (LTED)
The TED (Treasury-Euro Dollar) spread is measured as the difference between US Eurodollar deposits (three-month USD LIBOR) and US Treasury bills, and is commonly used in the literature to detect episodes of 'flight to quality.' According to Brunnermeier (2009) and Hammoudeh et al. (2011), the TED spread is an indicator of credit risk: it captures the difference in yields between unsecured *top-rated* interbank and government "riskless" credits. During stress periods and uncertainty, banks increase the interest rates on unsecured loans, driving up the interbank rate, thus destabilizing the liquidity of the equity market and the liquidity of the margin loan market (Boudt et al., 2017).
In constructing the IFEFSI, we adapt the TED spread to the Lebanese economy to become the Lebanese TED spread. It measures the spread between the interbank rate (the interest rate that banks lend to other banks in the local currency) and the interest rate at which the government

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[6] This is the act of substituting riskier government bonds and T-bills for safer ones.

is able to borrow money for 3 months (also in LBP). The LTED spread is hence, a proxy for funding illiquidity.

3.1.3 Beta of Banking Sector (BETA)

The standard capital asset pricing model (CAPM) is designed to capture the systematic risk of the industry. For example, beta of the banking sector represents that sector's market risk (Perold, 2004). Since betas are generally not time invariant, methods such as the GARCH model and the rolling-regression model have been frequently used to estimate the evolution of betas. More recently, betas are being used for financial stability purposes in order to estimate the cost of equity and to measure the level of financial stress (Barnes and Lopez, 2006). The banking sector's beta variation has been studied by Barnes and Lopez (2006), Caporale (2012), King (2009), Lie et al. (2000), among others. They analyzed the extent of synchronization between the banking sector movement and the overall stock market index. If beta is greater than one, then the banking sector is relatively riskier compared to the overall stock market.

For the IFEFSI, the beta of the banking sector is measured as the correlation (12 months rolling window) between the total returns of the banking-sector stocks and the BLOM market index (BMI) divided by the BMI's variance.

3.1.4 Loans from Central Banks to Commercial Banks (LOAN)

Loans from the Central Bank to commercial banks indicate liquidity shortages and are usually associated with stress periods (see, Irani and Meisenzah, 2017). By using international reserves to alleviate liquidity problems, the economy could potentially be exposed to a currency crisis. Indeed, recently the IMF country report for Lebanon (IMF, 2017), warned that "A common shock to bank liquidity, leading to a demand for foreign currency, could result in a drop in international reserves (1 percent of deposits are equivalent to 3.7 percent of reserves)."

Regardless of the source of funds (required reserves at the central bank or government and BDL securities as collateral for repo operations), BDL loans act to reinforce individual banks' liquidity positions in Lebanese pounds. Loans to commercial banks is included in the construction of the IFEFSI as a percentage change, where higher values indicate more stress and vice versa.

3.1.5 Weighted Average Cost of Capital (WACC)

The cost-of-capital (CC) of a company represents the rate of return that it should offer to compensate its investors for the capital they provide (Brealey et al., 2009; Emery et al., 2004). Equity and debt--considered as the main funding sources of a bank's capital--are not necessarily equal. Therefore, estimating different weights that reflect a bank's structure becomes important (Baker et al., 2011; Ionici et al., 2011). Hence the use of the WACC, which represents the cost of using equity and the cost of using debt relative to the percentage usage (Ionici et al., 2011).

The cost of debt is obtained from the weighted interest rate on long term deposits (term and sight savings) in both local and foreign currencies for residents and non-residents, after deducting corporate taxes. Cost of equity is calculated using the CAPM model:

cost of equity = risk free rate + beta of banking sector * market risk premium

The risk free rate is assumed to be the yield on the three months Treasury Bills. The market premium is the difference between the returns of the BMI and the risk free rate. Clearly, a

riskier overall banking sector, leads to a higher required rate of return, which in its turn leads to a higher WACC.

3.2 Equity Market

It has been found that financial openness boosts GDP growth and contributes to a greater expansion of the banking sector (Arcand et al., 2015; Bekaert et al., 2005; Kose et al., 2004, 2009; Mishkin, 2007; Obstfeld, 2009; Popov, 2017; Ranciere et al., 2006; Reinhart and Tokatlidis, 2005). Moreover, it can ensure welfare growth (Kalemli-Ozcan et al., 2009). Hence, many Asian and Latin American emerging countries have opened their financial market with different degrees of liberalization (or with some speculation restrictions) in order to benefit from these promising advantages (Loots, 2002). More recently, the causality between financial openness and economic growth has been tested for African and Arab countries (see, e.g., Abduh et al., 2012; Al-Malkawi et al., 2012; Masih et al., 2009; and Wolde-Rufael, 2009). The findings indicate that financial openness and economic growth seem to be positively related with minor differences across countries.

Lebanon is lagging behind in terms of opening its stock market compared to emerging countries. The Lebanese stock market, Beirut Stock Exchange (BSE), although being historically the second oldest market in the Middle East and North African region (established in 1920),[7] is relatively small in terms of traded volume, number of listed companies, and liquidity. It has only ten listed companies, with a market capitalization of about 24 percent of GDP versus 40 percent for a peer group of middle-income countries (IMF, 2017). More than 90% of the aggregate trading volumes and aggregate stocks are accounted for by commercial banks. Real estate and industrial equities constitute together less than 10%. The BSE lacks any sophisticated financial instruments and derivative products.

The low degree of openness of the BSE can be perceived as a strategy or a policy of mitigating possible contagion of international shocks through the stock market channel, especially that the Lebanese financial market does not seem to be well equipped with financial instruments to face critical international economic situations. When a stock market crisis hits an economy, other neighboring countries can potentially suffer as well. During stress periods, exaggerated irrational behaviors of international investors can cause contagion and spillovers among financial and capital markets. Moreover, BSE cannot guarantee the positive returns of openness if the whole economic structure is fragile. Ben Grama and Clévenot (2007), Bénassy-Quéré and Salins (2005), Kaminsky and Schmukler (2002), Obstfeld (2009), Ranciere et al. (2006), and Williamson and Mahar (1998), among others, have shown that in case of incompatibility with internal economic weaknesses, capital market openness can weaken the internal financial system, increase risk, and therefore, increase the probability to end up with a financial crisis.

Despite its weaknesses, the BSE still remains a channel for transmitting investors' uncertainties, and is hence included in constructing the IFEFSI.

3.2.1 Stock Market Volatility (STKVOL)
During periods of increased uncertainty, the stock market index becomes more volatile. In constructing the IFEFSI, we include the time-varying stock return volatility derived from a GARCH (1,1) specification to detect higher volatility, which implies higher stress.

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[7] The first one being the Egyptian stock market that was established in 1883.

3.2.2 Stock Market Return (STKR)

Historically, the capital market crises in developed and emerging countries have resulted from a sharp fall of stock prices after a "bubble" or in other words after being higher than they should be based on the fundamentals or as predicted by standard models (Evanoff et al., 2012; Garber, 2001; Reinhart and Rogoff, 2009; and Scherbina, 2013). Not unlike most financial crises, stock market crashes result from a collective change of investors' behaviors vis-à-vis expectations, net worth positions, consumer confidence, household sentiment etc. The IFEFSI includes the stock market return growth rate multiplied by -1, such that a decline of stock price returns increases the stress index and vice versa.

3.3 The Foreign Exchange and Debt Markets

A currency crisis has been generally considered to be the most widespread and severe type of crises in the past few decades. It takes many years to recover from a currency crisis because of its tight connection with other markets, such as the banking sector and the stock market. Regardless of how currency crises in Latin American and Asian emerging countries were analyzed and regardless of the conclusions found by numerous researchers, all currency crises result from a misalignment of the exchange rate regime (Frankel, 1999).

According to Bordo (2003, 2004), an appropriate exchange rate regime should be "up to date" and compatible with: (i) the degree of openness of the financial market, (ii) the capital mobility of the economy, (iii) the inflation level, (iv) the internal and external shocks, (v) prices and wages flexibility degree, and (vi) the monetary authority flexibility. Moreover, Devereux and Engel (2003) and Obstfeld (2006) have shown that a dollarized country should adopt a fixed exchange rate regime to mitigate and hopefully avoid probable future currency crises.

In the early 90s, at the end of the civil war, the Lebanese economy had witnessed some fundamental changes: significant increase in debt, adoption of expansionary policies, irrevocable dollarization with a continuous increasing trend, etc. As a result, in 1997, the BDL revised its *de jure* floating exchange rate regime to a *de facto* regime fixed to the dollar exchange rate, so to better match the economy's structural changes.

Currently, Lebanon is highly indebted in foreign currency thus rendering its economy fragile and prone to severe financial crises if any devaluation occurs (Eichengreen and Hausmann, 1999; Eichengreen et al., 2007). This requires its central bank to adopt a "more fixed" exchange rate regime (Calvo and Reinhart, 2002; Mishkin and Savastano, 2001) or even to become more dollarized. In conclusion, the Lebanese monetary authority will always have the "Fear of Floating[8]" as long as it suffers from the "original sin.[9]"

3.3.1 Exchange Market Pressure Index (EMPI)

High exchange rate volatilities decrease investors' confidence in the economy and might cause over-reaction that leads to financial instability (Kindleberger, 1996). If depreciation occurs in Lebanon while it is highly indebted in foreign currencies, debt weights become heavier thus

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[8]Calvo and Reinhart (2002) used this term to express the primary need of fixing exchange regime in vulnerable countries.
[9] Eichengreen and Hausmann (1999) and Eichengreen et al. (2007) called the failure of a country to get debt in local currency, thus accumulating debt in foreign currency and exposing the economy to a major financial crisis, the "original sin."

making the country vulnerable to a crisis (Calvo, 2006; De Nicolo et al., 2005; and Reinhart et al. 2003).

Given that Lebanon has a fixed exchange rate, in order to measure the currency risk, we construct an Exchange Market Pressure Index (EMPI). The EMPI was first introduced by Girton and Roper (1977) and advocated by Eichengreen et al. (1995, 1996). Later on, this index was extended by Berg and Pattillo (1999), Cerra and Saxena (2002), Edison (2003), Kamin et al. (2007), and Kaminsky et al. (1998). Moore and Wang (2009) and others have considered the EMPI to be an early warning indicator for currency crises.

This calculation is based on a weighted average of the changes in exchange rate, foreign exchange reserves, and interest rates as follows:

$$EMP_t = \alpha \Delta e_t - \beta \Delta r_t + \gamma \Delta i_t$$

Eichengreen et al. (1995; 1996) and Pontines and Siregar (2008) have proposed an EMPI version that is appropriate for a developing country such as Lebanon.

$$EMPI_{i,t} = \{(1/\sigma_e)* (\Delta e_{i,t}/e_{i,t})\} - \{(1/\sigma_r)*(\Delta rm_{i,t}/rm_{i,t} - rm_{0,t}/ rm_{0,t})\} + \{1/\sigma i * (\Delta(i_{i,t} - i_{0,t})\}$$

where $e_{i,t}$ is the Lebanese pound per one dollar in period t;
σi is the standard deviation of the nominal interest rate differential between country i and the anchor country.
σ_e is the standard deviation of the relative change in the exchange rate;
$rm_{i,t}$ is the ratio of gross foreign reserves to money stock for country i in period t;
$rm_{0,t}$ is the ratio of gross foreign reserves to money stock for the anchor country (U.S.) in period t;
σ_r is the standard deviation of the relative changes in the ratio of foreign reserves and the money base in country i and the anchor country; and
$i_{i,t} - i_{0,t}$ represents the difference between Interbank rate in LBP and in USD-Fed Fund.
All changes in this model consist of 12 months' changes.

A higher value of EMPI, indicating that the exchange rate is under pressure, will raise the IFEFSI and vice versa.

3.3.2 Financial Dollarization (DOLL)
Since the early 90s, the dollarization rate (financial dollarization) in Lebanon has always been around 70%, one of the highest dollarization rates in the world after Angola, Armenia, Azerbaijan, Bolivia and Cambodia. A high dollarization rate is usually associated with weak institutions (De Nicolo et al, 2005). It reflects preferences of economic agents to hold cash and/or to make deposits in foreign currency rather than in the local currency because of lack of trust and weak confidence (Catão and Terrones, 2016). Several studies have found that money demand in foreign currencies in dollarized countries is highly correlated with sudden stop and systemic crises (Calvo et al., 2008; Durdu et al., 2009; Gonçalves, 2007) providing confirmation that the dollarization rate is a good financial vulnerability indicator.
The IFEFSI includes financial dollarization measured as the deposits in foreign currencies to the total deposit of residents and nonresidents. Since the US dollar has traditionally been more stable than the Lebanese pound in terms of currency value and purchasing power level, a higher value of the ratio reveals a higher stress period. An increase of the indicator's value is associated with economic, political and geopolitical troubles, and will increase the value of the IFEFSI.

3.3.3 Debt in foreign currencies over total debt (EDTD)

Debt in foreign currency called partial dollarization is relatively high in Lebanon and around fifty percent of its total debt. The motive of dollarizing debt in Lebanon, a country that lacks confidence and trust in its local currency, is to promote credibility. In fact, debt in foreign currency (FX Debt) disables the monetary authorities' ability to devalue its local currency by creating money to fill a budget deficit (Calvo and Mishkin, 2003). In spite of this advantage, debt denominated in foreign currencies is considered as one of the most vulnerable indicators that make an economy subject to a severe financial crisis. In practice, the higher the FX debt, the lower the scores obtained from the rating agencies on international capital markets (Goldfajn and Olivares, 2001).

The debt risk of a country (sovereign debt risk) is usually proxied by taking either the foreign debt to total debt ratio or the short term external debt (STED) to total debt ratio. Although the second ratio is considered to be a more informative vulnerability indicator, the IFEFSI includes the foreign debt to total debt because STED data are unavailable on a monthly basis.

3.3.4 International Reserves

Theoretically, International Reserves (IR), also known as foreign reserves come mainly from the excess of trade balance. However, Lebanon's trade balance has been in deficit for a very long time. Given the way IR is calculated for Lebanon, we are concerned that including IR as an indicator will lead to double counting and biasedness in the final index, so we have opted to leave it out from our calculations.

4. Methodology

Once all indicators are standardized, the next step is to choose the most adequate aggregation method. Several methods have been used in the literature such as: factor analysis, principal components analysis (PCA), variance equal weights (VEW), economic weights, cumulative distribution functions (CDF), and others. See Table A-1 in the appendix for a list of studies and the methods used. Similarly to the IMF studies (Balakrishnan et al., 2009, 2011; Cardarelli et al., 2011), we adopt the Variance Equal Weight (VEW), which is the most frequently used weighting method in the literature. Given that the PCA works better for highly correlated and ours are not (see Table A.2 in the Appendix), it will be used as a robustness check.

4.1 Equal Variance Approach

The IFEFSI shown in figure 1 is a composite index that includes the simple sum of ten standardized indicators, each having an equal weight of one. Recall that all indicators are standardized, therefore, a one unit change in an indicator results in a one standard deviation change in the final index. As mentioned before, higher positive values of the stress index indicate stress periods, while negative values indicate calm periods.

Figure 1: IFEFSI (variance equal weighting method)

IFEFSI (VEW)
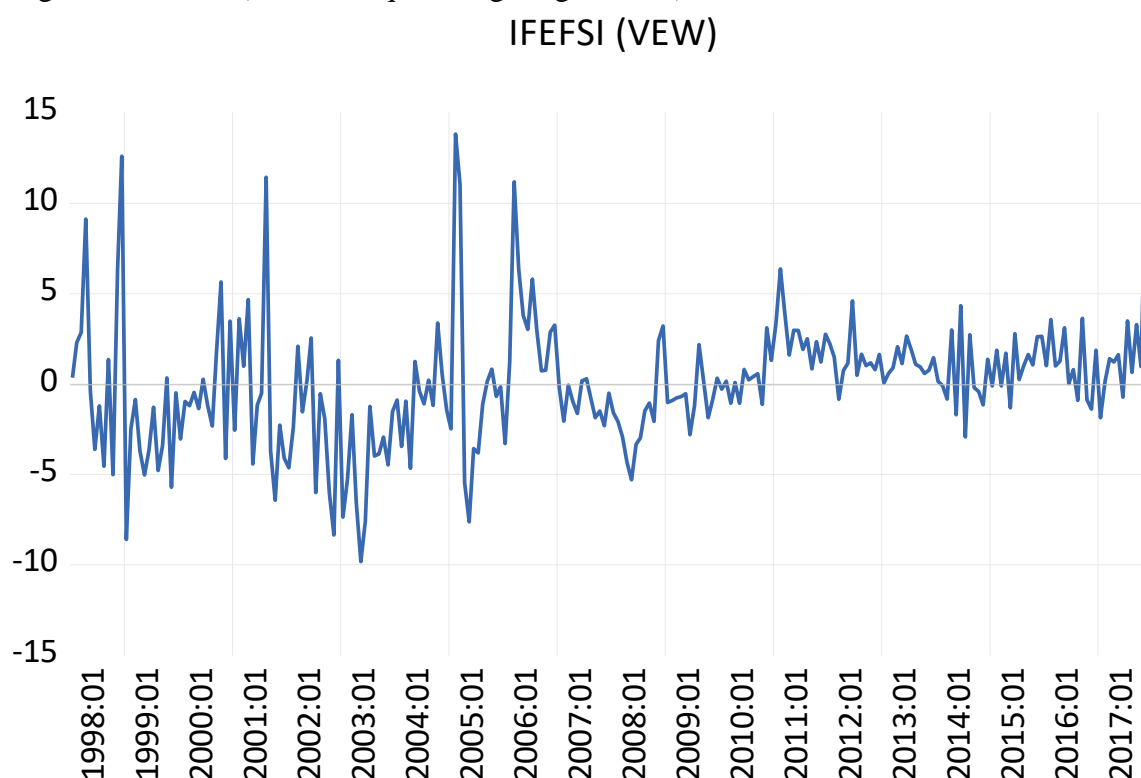
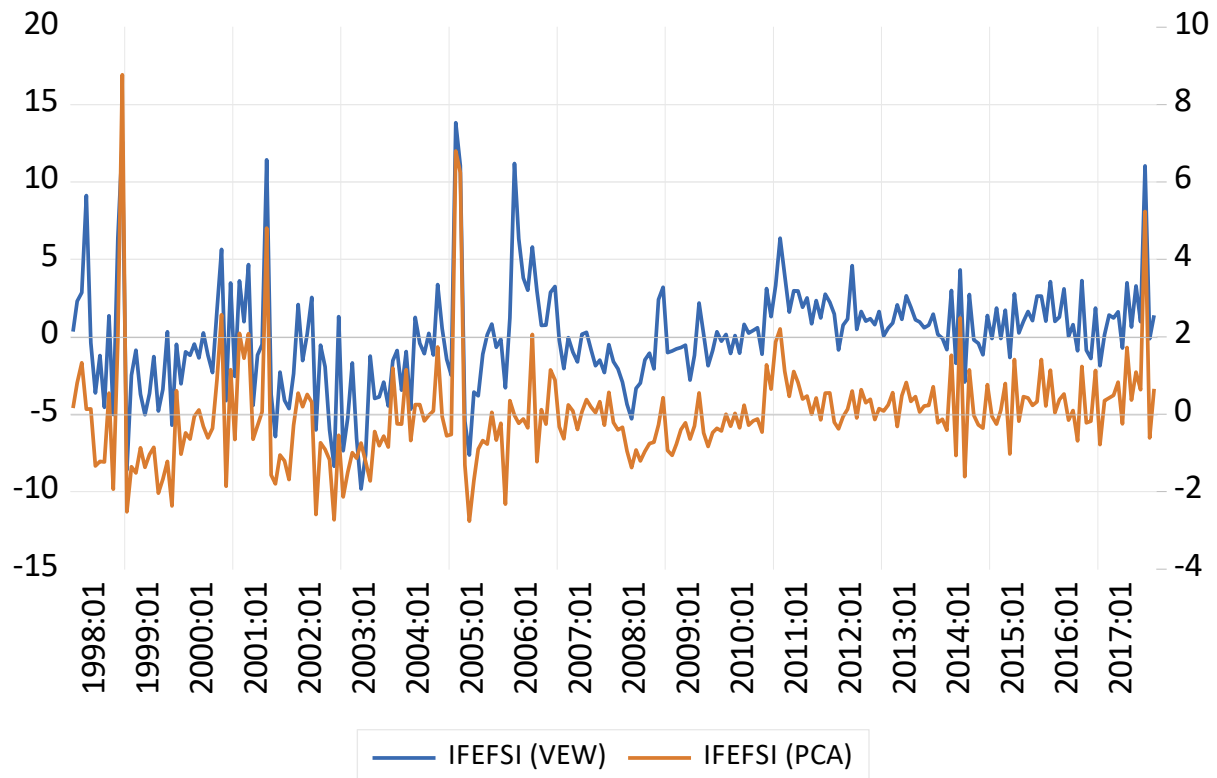*Source: Authors' calculation*

4.2 Robustness checks

Initially developed in the 1930s by Harold Hotelling, the PCA is a statistical procedure that orthogonally transforms a set of observations of possibly correlated variables into a set of uncorrelated variables called principal components. A major drawback of this method is that it minimizes the contribution of individual indicators which do not move with other individual indicators (OECD, 2008).

The set of principal components for our set of variables is shown in Table A.3. Using the first principal component (eigenvalue 1.79) which explains 18% of the total variation, we obtain the associated loading factors or weights for each variable (see Table A.4). The final index is then constructed by multiplying each variable by its weight and summing them up.

Figure 2 shows the IFEFSI derived using the VEW methodology measured on the left axis, as well as the IFEFSI derived using PCA analysis measured on the right axis. As can be seen from figure 2, both series have very similar trends. Not surprisingly, their correlation is 83.45 %.

To better compare the two approaches, the reader should remember that by taking the sum of ten variables in the VEW, we have effectively multiplied each variable by a weight of 1. If this common weight is compared to the ones listed in Table A.4, it is clear that the main difference is in the weight of the stock market sector represented by STKVOL and STKR. Hence, the IFEFSI-VEW considers the stock market to be as important as the banking sector and the exchange and debt markets, while the IFEFSI-PCA gives very little weight to the stock market.

Figure 2: IFEFSI using the VEW methodology and the PCA methodology

IFEFSI (VEW) — IFEFSI (PCA)

Source: Authors' calculation

5. IFEFSI Interpretation

In this section we will discuss the IFEFSI peaks and troughs and try to relate them to financial, economic, or political events. This is best done by adding the business cycle economic expansions and contractions to the figure as done in figure 3. The business cycle for Lebanon is constructed by Jad (2017) following Bry and Boschan's (1971a, 1971b) methodology, and based on the coincident indicator that is released by BDL on a monthly basis. Given the weaknesses in calculating Lebanon's GDP, the coincident indicator is usually taken as a good proxy for the GDP.

Figure 3: The IFEFSI and the business cycle from 1998 to 2018.
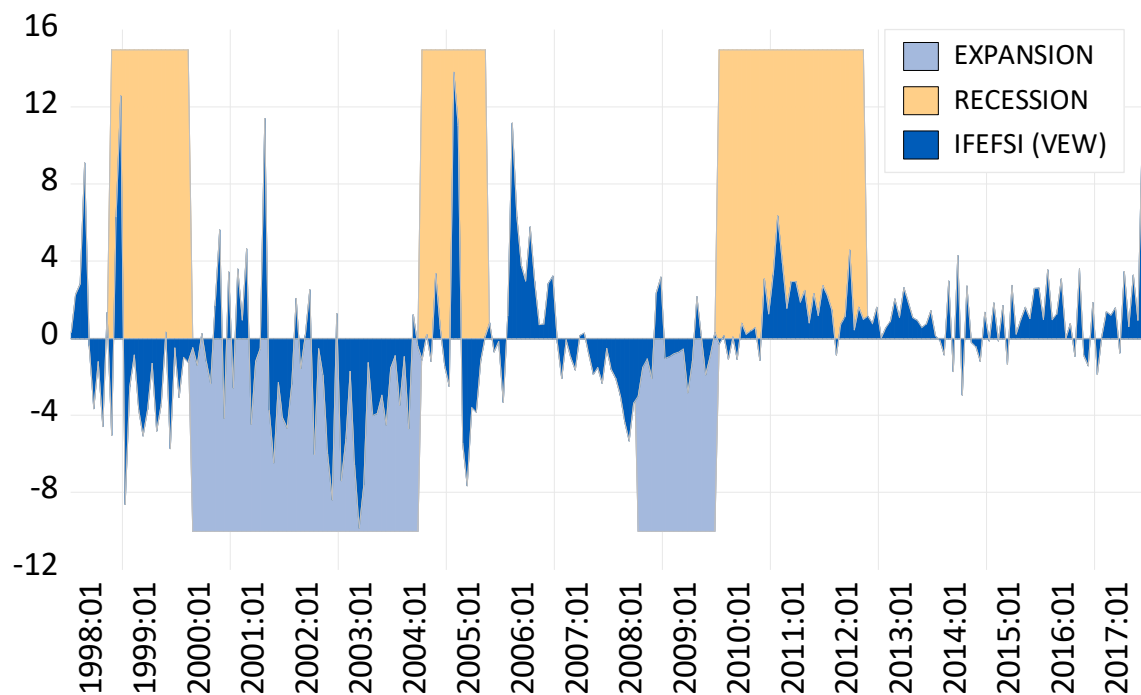
- Prior to 2005, Lebanon witnessed a series of financial stress episodes as indicated by the high positive spikes of the IFEFSI. Only one seem to have been followed by a recession, while the other take place during a recession or during an expansionary period. The majority of these stress periods coincide with political turmoil, mainly related to armed conflicts with Israel. An exception, however, is the July 2001 peak, which is related to an economic event; Moody's first downgrade of Lebanon to B2 from its initial rating of B1 that was granted in February 1997.

- Clearly, one of the most severe stress periods falls in February 2005, when the prime minister Rafic Hariri was assassinated. The late former prime minister was a symbol of security and prosperity for Lebanon. In the early 2000s, Lebanon had witnessed the highest economic growth ever as a result of Hariri's expansionary policies that promoted reconstruction, new infrastructure, more employment, etc. His assassination raised panic in the country, represented by a sudden and complete shift in the IFEFSI to reach a high peak.

- The high stress period in early 2006 is due to the sharp decline in the stock market index. In fact, GCC investors started to sell their positions in listed Lebanese companies to cash-in their profits after a sustained increase in the local stock market, as well as due to their need for liquidity at the time, for other investments.

- In July 2006, Lebanon suffered from an Israeli attack. The one month-long destructive war caused many citizens to become displaced or homeless, and destroyed major infrastructure in the country. Surprisingly, the stress index during that period was not as high as expected. In fact, during this period, the BDL had taken emergency measures aimed at containing and limiting any financial or economic problems. For example, it prohibited the conversion of large amounts from Lebanese Pound to US Dollar. This action effectively has prevented economic agents from expressing their fear, worry, uncertainty through banking operations and the foreign exchange market. Moreover, the Beirut Stock Exchange was closed from July 17, 2006 until July 31, 2006. As a result, BDL's measures were successful in avoiding

any financial catastrophe and helped maintain a relatively stable stock market. Indeed, the governor of BDL was awarded the 2006 Euromoney Award as the best Central Bank Governor in the world in terms of overcoming crises and wars.

- It is striking that the recent global financial crisis--the subprime crisis of 2008—was not felt in Lebanon. Accordingly, the IFEFSI does not detect any major stress episodes during that period, in contrast to most other FSIs in the literature. On the contrary, the index shows that during this period, Lebanon enjoyed an economic expansion, represented graphically via negative values of the IFEFSI. Again, this is not surprising that Lebanon and is expected to happen given our relatively closed stock market, the fixed exchange rate regime, and the lack of speculation and availability of any sophisticated financial instruments.

- Recently, in November 2017, Lebanon suffered from a major stress period related to an ambiguous incident during prime minister Saad Hariri's visit to Saudi Arabia. Rumors abound about his arrest in the Kingdom, which caused the spreading of panic and uncertainty in the Lebanese financial markets. Large withdrawals of customer deposits led to a liquidity shortage for some banks, and pushed up the interbank rate to reach six-fold its average rate. Moreover, conversion operations form local currency to safer foreign currencies destabilized the foreign exchange and debt markets. Overall, although the politic crisis persisted few days, by December 2017 the negative impacts had subsided as can be seen from the figure.

The next step would be to more carefully analyze the relationship between the IFEFSI and the economy. Many studies have found that financial crises are usually associated with a recession especially in developing and emerging countries (Hong et al., 2010; Tng and Kwek, 2015) and paradoxically, the economy can benefit from a prolonged period of low stress (Reinhart and Rogoff, 2014).

6. Conclusion

In this paper we develop Lebanon's first Financial Stress Index, dubbed the IFEFSI (Institute of Financial Economics Financial Stress Index). Although we broadly follow the IMF methodology, care is taken to tailor the index to Lebanon and make sure that it reflects its particularities as a developing country in the Middle East. The IFEFSI is considered to be a broad coincident composite index that starts in January 1998, has a monthly frequency, and is customized to include the relevant market segments and indicators.

The final IFEFSI is composed of three major market segments; the banking sector, the equities market, and the foreign exchange and debt markets, each including a selection of representative vulnerability indicators. Higher positive values signal more financial distress and lower negative values indicate relatively calmer periods. Unlike most other FSIs in the literature, the IFEFSI does not detect international financial crises such as the dotcom crash (2000-2001) or the subprime crisis (2008-2009). We find that the Lebanese financial markets are more vulnerable to domestic and perhaps regional instabilities, than to international ones. Moreover, political (or geopolitical) events seem to affect financial markets more than economic developments.

The IFEFSI is a metric for financial conditions that can detect any financial instability and warn us about worsening financial distress. FSI's are frequently used by central banks and monetary authorities to monitor the financial markets' situation, assess the soundness of financial systems, and help in a more efficient crisis management and prevention. The IFEFSI should provide valuable information to Lebanese macroprudential regulators whose aim is to

maintain a smooth and resilient financial system. By using it as a tool to help monitor, identify, and address any potential crisis, they are better equipped to maintain financial and economic stability in Lebanon.

Besides measuring and detecting Lebanese financial fragility, our aim is to extend this work and study more carefully the relationship between IFEFSI and economic conditions. Further analysis is needed to understand the relationship between the IFEFSI and economic recessions and expansions. In future work, the IFEFSI will be decomposed into its three markets to investigate whether the relationship with the economy is dependent on the source of the stress or not. Deconstructing the index can also help clarify the relationship between the composite and its components. Another application of the IFEFSI, is to construct a model to shed more light on the likelihood of reaching a higher (or lower) stress regime based on a set of related variables. These variables can include economic variables, geopolitical measures, and others.

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Appendix

Table A.1 - Summary of Selected Financial Stress Indexes

Authors	Year	Country	Aggregation Method	Indicators
Illing and Liu	2003	Canada	Credit weighting	1- Exchange rate volatility 2- Covered Canada-US 90 day Treasury spread 3- Commercial paper-Treasury bill rate spread 4- Corporate bond yield spread 5- Beta of banking sector 6- Bond yield spread of banking sector 7- Bid-Offer spreads on Canadian Treasury bills 8- Inverted yield curve 9- Equity risk premium
Hanschel and Monnin	2005	Switzerland	Equal weighting	1- Bank-issued bonds spreads 2- Bank stock price index 3- Provisions rates of bank sector 4- Return on assets of the banking sector 5- Total assets of banks under special scrutiny according to the banking supervisory authority of Switzerland 6- Total interbank deposits 7- Variation in bank capital 8- Number of bank branches
Hansen	2006	Denmark	Equal weighting	1- Emerging market spread 2- Corporate spread between AA corporate debt and government debt in the euro area 3- Corporate spread between BBB and AAA corporate debt 4- Swap spread 5- Bond implicit volatility derived from a 1 year/1 year swaption 6- Bond implicit volatility derived from a 1 year/10 year swaption 7- Stock implicit volatility

				8- Excess return of government bonds over stocks
Illing and Liu	2006	Canada	Credit weighting	see Illing and Liu (2003)
Misina and Tkacz	2008	Canada	see Illing and Liu (2006)	see Illing and Liu (2006)
Cardarelli et al.	2009	17 developed countries[10]	Equal weighting	1- Exchange rate volatility 2- Corporate bond-long term government bond spread 3- Beta of banking sector 4- Inverted term spread 5- TED spread 6- Stock market returns 7- Stock market volatility
Balakrishnan et al.	2009	26 emerging countries[11]	Equal weighting	1- Beta of banking sector 2- Stock market returns 3- Stock market volatility 4- Sovereign debt spreads (the bond yield minus the 10 year US Treasury bond) 5- Exchange market pressure index (capturing changes in exchange rate and international reserves)
Hakkio and Keeton	2009	US	PCA	1- AAA Treasury yield spread 2- Baa-Aaa corporate bond spread 3- Stock bond correlation 4- High yield bond Baa spread 5- Cross section dispersions of bank stock returns 6- Swap spread 7- Off the run-on the run Treasury spread 8- TED spread 9- Idiosyncratic volatility of banking stock prices 10- Stock market volatility 11-Consumer ABS Treasury spread

[10] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United states

[11] Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, Slovak Republic, Slovenia, South Africa, Sri Lanka, Thailand, and Turkey

Central Bank of the Republic of Turkey	2009	Turkey	Not available	1- Exchange market pressure index (combining changes in exchange rate and international reserves) 2- Emerging markets sovereign bond index 3- Stock market returns 4- Stock market volatility 5- Beta of the banking sector
Melvin and Taylor	2009	17 developed countries[12]	Equal weighting	see Cardarelli et al. (2009)
Kliesen and Smith	2010	US	PCA	1- Federal Funds rate 2- 2 year Treasury yield 3- 10 year Treasury yield 5- 30 year Treasury yield 5- Baa corporate bond yield 6- Merrill Lynch US High yield corporate master II Index 7- Merrill Lynch Asset backed master BBB rated 8- 10 year Treasury-3 years Treasury spread 9- LIBOR-Overnight Index Swap spread 10- TED spread 11- 3 month commercial paper-3 month treasury spread 12- Baa corporate bond-10 year Treasury yield spread 13- Merrill Lynch US High yield master II Index-10 year Treasury spread 14- 10 year nominal Treasury-TIPS yield spread 15- JP Morgan Emerging market bond index 16- Vanguard financial exchange-traded fund 17- Merrill Lynch bond market volatility index 18- Chicago Board Options Exchange Market volatility index

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[12] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United states

Yiu et al.	2010	Hong Kong	Equal weighting	1- Banking distress indicator 2- Option-implied volatility of exchange rate 3- Hong Kong Exchange Fund note-US Treasury note spread 4- Inverted term spread 5- TED spread 6- Stock market volatility
Sandahl et al.	2011	Sweden	Equal weighting	1- Exchange rate volatility 2- TED spread 3- Stock market volatility 4- Covered bonds-government bond spread
Slingenberg and Haan	2011	13 OECD countries[13]	Equal weighting	1- Stock market volatility 2- Corporate bond spread 3- TED spread 4- Beta of banking sector 5- Exchange rate volatility
Oet et al.	2011	US	Credit weights	1- Financial beta 2- Bank bond spread 3- Interbank liquidity spread 4- Interbank cost of borrowing 5- Weighted dollar crashes 6- Covered interest spread 7- Corporate bond spread 8- Liquidity spread 9- Commercial paper-Treasury Bill spread 10- Treasury Yield curve spread 11- Stock market crashes
Hollo et al.	2012	Euro Area	Equal weighting for indicators and time varying correlations for sub-indexes	1- Euribor volatility 2- Money market spreads 3- ECB marginal lending 4- Government bond volatility 5- Non-financial bond spread 6- Swap spread 7- Non-financial stock volatility 8- Non financial stock CMAX (Maximum cumulated index losses) 9- Stock-bond correlation

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[13] Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, United Kingdom, and United States

				10- Stock market volatility of banking sector 11- Financial vs nonfinancial bond spread 12- Financial book price ratio 13- Euro-US dollar volatility, Euro-Yen volatility, and Euro-British Pound
El-Shal	2012	Egypt	see Balakrishnan et al. (2009)	see Balakrishnan et al. (2009)
Tng et al.	2012	5 ASEAN countries[14]	Credit weighting	1- Beta of banking sector 2- Returns of banks stocks relative to overall stock market 3- Stock market returns 4- Stock market volatility 5- Exchange market pressure index (combining changes in exchange rate and international reserves) 6- Residuals of regressing Treasury yields on interbank interest rates
Cevik et al.	2013	5 European countries[15]	PCA	1- Banking sector fragility index (based on assets and liabilities) 2- Stock market volatility 3- Exchange market pressure index (combing changes in exchange rate, international reserves, and overnight interest rate relative to the US) 4- External debt growth rates 5- Sovereign risk (using contingent claim analysis) 6- Trade finance (using external short-term debt and financial flows)
Cevik et al.	2013	Turkey	PCA	1- Default probability of the banking sector 2- Beta of Stock Market

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[14] 5 members of the Association of South East Asian Nations (ASEAN): Indonesia, Philippines, Malaysia, Singapore, and Thailand
[15] Bulgaria, the Czech Republic, Hungary, Poland, and Russia

				3- Exchange market pressure index (combing changes in exchange rate and international reserves)
				4- Short term and total external debt growth rates
				5- Sovereign bond spreads (Turkey's Emerging Market Bond Index and 10-year US Treasury yield spreads)
				6- Trade finance (using financial account balance in the balance of payments)
				7- Claims on the private sector growth rates
				8- Bid–ask spreads in the overnight interest rate and the foreign exchange market
				9- Bid–ask–spreads in the stock market
Louzis and Vouldis	2013	Greece	PCA for indicators and time varying correlations for sub-indexes	1- 10 year Greek Government Bond-German Bund spread 2- Yield realized volatility 3- Stock bond correlation 4- Stock market prices of the banking sector 5- Idiosyncratic risk of stock market prices of the banking sector 6- Greek banks CDS spreads 7- Deposit gap of banks 8- Loan gap of banks 9- Interest margins (profitability) of banks 10- Stock market prices 11- Stock market volatility 12- Earnings per share 13- 3 month Euribor-3 month German T-bill spread
Lo Duca and Peltonen	2013	28 emerging and advanced economies[16]	Equal weighting	1- Interbank rate and government rate spreads 2- Stock market returns 3- Stock market volatility 4- Nominal effective exchange rate volatility 5- Yield on government bill volatility

[16] Argentina, Australia, Brazil, China, Czech Republic, Denmark, Euro area, Hong Kong, Hungary, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, Norway, Philippines, Poland, Russia, Singapore, South Africa, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, and United States

Ekinci	2013	Turkey	Equal weighting	1- Interbank cost of borrowing 2- Turkey five year USD credit default swap spreads 3- Stock index returns changes 4- Exchange rate changes
Magkonis and Tsopanakis	2014	G7 countries[17]	see Cardarelli et al. (2009)	see Cardarelli et al. (2009)
Christensen and Li	2014	13 OECD countries[18]	see Cardarelli et al. (2009)	see Cardarelli et al. (2009)
Zigraiova and Jakubik	2015	14 developing and advanced countries[19]	Market equal weighting	1- Stock market returns 2- Stock market volatility 3- Nominal exchange rate volatility 4- TED spread (for some countries, the inverted interest rate spread is used instead) 5- Yield on 3 month Treasury bills volatility (for some countries, the yield on long term government bonds is used instead)
Dahalan et al.	2016	Malaysia	PCA	1- Banking sector fragility index 2- Stock market volatility 3- Exchange market pressure index (combing changes in exchange rate and international reserves) 4- Sovereign bond spread 5- Claims on private sector growth rates 6- External debt growth rates
Cevik et al.	2016	5 Asian countries[20]	Dynamic factor model	1- Banking sector returns volatility 2- Stock market volatility 3- Exchange market pressure index (combing changes in exchange rate, international reserves, and overnight

[17] Canada, Germany, Japan, United Kingdom, United States, France and Italy
[18] Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom and United States
[19] Argentina, Czech Republic, Euro Area, Hungary, Japan, Korea, Mexico, Russia, Sweden, Switzerland, Thailand, Turkey, UK, and United States
[20] Indonesia, South Korea, Malaysia, Philippines, and Thailand

				interest rate relative to the US) 4- Ratio of short term external debt to GDP 5- Sovereign risk (using contingent claim analysis)
Magkonis and Tsopanakis	2016	G5 countries[21]	see Cardarelli et al. (2009)	see Cardarelli et al. (2009)
Aboura and Roye	2017	France	Dynamic factor model	1- TED spread 2- Money market spread 3- Beta of banking sector 4- Stock market index of banking sector 5- Expected Lending 6- CDS on banking sector 7- Banking sector volatility 8- Term spread 9- Corporate credit spread 10- Housing credit spread 11- Consumer credit spread 12- CAC 40 log-returns 13- Stock market volatility 14- Government bonds spread 15- CDS on corporate sector 16- CDS on 10 year government bonds 17- Nominal synthetic exchange rate volatility
Duprey et al.	2017	27 European Union countries[22]	see Hollo et al. (2012)	1- Stock market volatility 2- Stock market CMAX 3- Bond market volatility 4- Cumulative difference corresponding to the maximum increase of the real government bond spread with respect to Germany 5- Real effective exchange rate volatility 6- Cumulative change of real effective exchange rate

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[21] Canada, Germany, Japan, United Kingdom, and United Stated
[22] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and United Kingdom

Table A.2- Correlation of variables

	INVY	LTED	LOAN	BETA	WACC	STKVOL	STKR	DOLL	EMPI	EDTD
INVY	1									
LTED	0.1631	1								
LOAN	-0.0408	-0.0369	1							
BETA	0.1737	0.0959	0.0161	1						
WACC	0.0067	-0.02	-0.0064	0.0099	1					
STKVOL	-0.351	-0.0259	-0.0655	0.1535	-0.2099	1				
STKR	-0.0038	-0.0219	0.0012	0.0076	-0.4437	0.059	1			
DOLL	-0.001	0.4	0.2172	0.0627	-0.006	-0.0306	0.0341	1		
EMPI	-0.0204	0.3602	0.1939	0.0105	-0.045	0.0046	0.0696	0.2803	1	
EDTD	-0.1084	-0.0226	0.0155	-0.0718	0.0298	-0.0227	-0.0435	0.0757	0.0616	1

Table A.3 - Eigenvalues for the PCA components

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.79	0.22	0.18	0.18
Comp2	1.57	0.24	0.16	0.34
Comp3	1.33	0.17	0.13	0.47
Comp4	1.16	0.15	0.12	0.58
Comp5	1.01	0.09	0.10	0.69
Comp6	0.92	0.20	0.09	0.78
Comp7	0.71	0.10	0.07	0.85
Comp8	0.62	0.16	0.06	0.91
Comp9	0.45	0.00	0.05	0.96
Comp10	0.45	.	0.04	1.00

Table A.4 - Principal component 1 loading factors

Variable	Comp1
INVY	0.0558
LTED	0.6487
LOAN	-0.0162
BETA	0.0749
WACC	-0.0135
STKVOL	0.0187
STKR	-0.0088
DOLL	0.5311
EMPI	0.51
EDTD	0.1655