A Financial Stress Index for a Highly Dollarized Developing Country: The Case of Lebanon

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Abstract

The aim of this paper is to construct the first comprehensive 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 other 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 Index, Financial Crisis, Lebanon, Economic Policy.

JEL: G01, G18, G20, E44, E58

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, and hence understudied, in the period before the 2008 global financial crisis. Consequently, financial markets were barely represented in macroeconomic models (Borio, 2014). Financial stress 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. [1]

Following the 2008 global financial crisis, we have seen a growing body of research investigating the effect of financial stress on the health of the economy. 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).

It is well-known that 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

[1] 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).

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 events, [2] that treat crises as system-wide events and may have early detection capabilities for financial stress episodes in a country (see, inter alia, Balakrishnan et al., 2009; Cardarelli et al., 2009; Christensen and Li, 2014; Duca and Peltonen, 2013; Duprey et al., 2017; Hollo et al., 2012; Melvin and Taylor, 2009; Slingenberg and De Haan, 2011; Zigraiova and Jakubik, 2015;). Predominantly, these studies use a financial stress index (FSI hereafter) to represent financial stress, due to its multiple advantages.

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., 2013a), 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. It is important to note here that by 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).

Since 2003, when the first country-level financial stress index 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; for example, among others,

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

Cevik et al. (2013b) for Turkey, Dahalan et al. (2016) for Malaysia, and El Shal (2012) for Egypt. Such methods-based indexes are preferable to expert-based approaches for several reasons.

Unfortunately, to date, Lebanon has relied on an expert-based approach for identifying financial stress episodes, but this method is plagued with weaknesses. For instance, 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. Moreover, a comprehensive index, can help identify events that are truly systemic, and not simply due to instability in a single market segment.

Hence, the main contribution of this paper is the construction of the first comprehensive Financial Stress Index for Lebanon named the Institute of Financial Economics Financial Stress Index. This is a broad index that includes three different market segments; the banking sector (comprises five indicators), the equities market (comprises two indicators), and the foreign exchange and other markets (comprises three indicators). It is constructed as a continuous contemporaneous measure that quantifies the level of systemic stress through aggregating the standardized variables using two methods (equal weighting and principal components analysis) to obtain the final IFEFSI. Mansour Ishrakieh et al. (2019) investigate the importance of the dollarization rate in heavily dollarized economies such as the Lebanese economy. They find it to be the single most important indicator with a correlation of 0.59 with the final index, and recommend that other similarly highly countries include the dollarization rate as an indicator in order to obtain a sound and accurate FSI.

Overall, 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. For example, the IMF's Staff Concluding Statement of the 2018 Article IV Mission (IMF, 2018), stresses that financial stability risks in Lebanon should be contained. This can be easily done by tracking an index such as the IFEFSI. The IFEFSI is expected to 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 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, FSIs are usually dominated by indicators related to prices such as stock market prices, while FCIs have also included other indicators (Kliesen et al., 2012), such as quantity indicators (loans to households) or even survey-based indicators such as a survey question on banks' access to market financing (Angelopolou et al., 2014). FSIs are also 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). In terms of the FSI series' frequency, the most common is the monthly frequency, followed by the daily then quarterly, and a few that have a yearly or weekly frequency.

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 global 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. (2013a) 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. (2013b) 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 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 other markets.

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.[3]

The BLOM index (BMI)[4] and six listed banks' returns are quoted on a daily basis by DataStream and Beirut Stock Exchange.[5] 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 obtained from the Banque du Liban (BDL is the Central Bank) 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] At the end of 1992, the Banque du Liban adopted a *stabilization policy* based on the exchange rate regime under which the Lebanese pound (LBP) appreciated from 1,838 pounds per USD at the end of 1992 to 1,515 pounds per USD at the end of June 1998 (Helbling and Eken, 1999).

[4] According to Bloomberg, "The BLOM Stock Index (BSI) is a capitalization-weighted index of all the listed companies on the Beirut Stock Exchange. The index was developed by Blominvest Bank with a base level of 1000 as of January 22nd, 1996."

[5] The six banks are: AUDI, Bank of Beirut, BEMO, BLC, BLOM, and Byblos.

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 exposed to stress and even to severe crises due to the following reasons: (i) the secondary market in government debt and the 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 term spread or yield curve, measured as the difference between the long-term and short-term interest rates, can be inverted when the short-term yield is larger than the long-term yield, hence the name inverted yield. A negative term spread, or an inverted yield curve, is considered to be one of the best leading indicators that can predict economic recessions in the upcoming months (Chinn and Kucko, 2015). For example, in the U.S. the time lag between

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

the yield inverting and the beginning of a recession has ranged between 6 and 24 months (Bauer and Mertens, 2018).

Besides predicting an economy's recession, the inverted yield signals tightened credits (Death of Credit), thus exposing banks to higher risks. Many economists (see, inter alia, 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) 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. Even though for developed countries and especially for the U.S. the slope of the yield curve is typically computed as the difference between the 10-year bonds and the 3-month T-bills, however for emerging and developing countries shorter maturities (less than 10-years) have been used. See, for example, Mehl and Reynaud (2005) who use the difference between the yield on the 5-year (in some cases 3 years or 1 year) Treasury bond and that of the 3-month Treasury bill for a group of emerging economies. 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 maturity bonds.

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 is able to borrow money for 3 months (also in LBP). The LTED spread is hence, a proxy for credit risk (Eom et al., 2002).

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 DCC-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 observations for the BMI and the banks are first transformed into market returns using the daily closing prices. Next, we convert them to a monthly frequency using the end-of-month (last trading day) observation, after which the monthly bank returns are averaged. 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 BMI divided by the BMI's variance (12 months rolling window).

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 BDL 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.

Admittedly, on one hand Lebanon's low degree of financial openness prevents it from benefitting from the advantages noted above, however on the other hand, it can protect Lebanon from contagion as a result of negative international shocks, given its fragile economic structure. For example, Lebanon was not negatively affected through its stock market by the 2008 global financial crisis. Moreover, 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 certain cases, 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.

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

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

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 Other Markets

A currency crisis has been generally considered to be the most widespread and severe type of crisis 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).

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, 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)

A proxy for the exchange rate is an important component of any FSI because high exchange rate volatilities decrease investors' confidence in the economy and might cause over-reaction that leads to financial instability (Kindleberger and Aliber, 1996). Although in a fixed exchange rate regime, such as the one in Lebanon, a bank run can be prevented, but only at the cost of causing a currency run (Wagner, 2000).

Given that Lebanon has a fixed exchange rate, we will use the exchange market pressure to measure the currency risk. The exchange market pressure is measured quantitatively by constructing a statistic from observed changes in exchange rate, foreign reserves of the central bank, and in some cases the short-term interest rate differential (Spolander, 1999). The Exchange Market Pressure Index (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.

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. A higher value of EMPI, indicating that the exchange rate is under pressure, will raise the IFEFSI and vice versa. Please refer to Appendix A for more details on the calculation of the EMPI.

[8]Calvo and Reinhart (2002) used this term to express the primary need of fixing exchange regimes 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."

3.3.2 Financial Dollarization (DOLL)

Since the early 90s, the dollarization rate (financial dollarization) in Lebanon has always been around 70%,[10] 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 ratio of 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,

[10] In this paper, any dollarization rate mentioned is the financial dollarization rate. The two terms are used interchangeably.

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,[11] 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 Appendix B 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 Appendix B), the PCA will be used as a robustness check.

[11] Figures A.1 to A.3 in Appendix B provide time plots of each normalized indicator by sector.

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.

Insert figure 1here

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 each indicator in the stock market to be as important as any indicator in the banking sector or the foreign exchange and other markets, while the IFEFSI-PCA gives very little weight to the stock market.

Insert figure 2 here

5. IFEFSI Interpretation

In this section we will discuss the IFEFSI main 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. We have also provided in Appendix C a series of economic events that are likely to have affected the FSI.

Insert figure 3 here

- Prior to 2005, Lebanon witnessed a series of financial stress episodes as indicated by the high positive spikes of the IFEFSI. Only one seems to have been followed by a recession, while the others take place during a recession or during an expansionary period. The majority of these stress periods coincide with political turmoil, such as difficulties to form a government, or are related to armed conflicts with Israel. An exception, however, is the July 2001 peak, which is triggered by 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. This was also exacerbated by Moody's downgrade of Lebanon's rating in March 2005.

- 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 2008 global financial crisis 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 low stress, represented graphically via negative values of the IFEFSI, and the economy was in an expansionary phase. Again, this is not surprising for Lebanon and is expected given

Lebanon's relatively closed stock market, its fixed exchange rate regime, and the lack of speculation and unavailability of any sophisticated financial instruments.

- As a result of the government resignation in January 2011 in the midst of some political instability, the IFEFSI spikes up reflecting some financial stress.
- Recently, in November 2017 during a prolonged period of slow economic growth, 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 spread 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 other markets. Overall, the politic crisis persisted only a few days, and by December 2017 the negative impacts had subsided as can be seen from the figure.

Interestingly, geopolitical stress has manifested itself through various indicators in the banking and foreign exchange and other market sectors, while the only non-politically induced stress event in early 2006 was expressed through a massive (and only) spike in the stock market volatility indicator. This also coincides with the highest spike in the stock return indicator occurring in February 2006. The next step would be to analyze the relationship between the IFEFSI and the economy quantitatively using econometric tools. 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 comprehensive Financial Stress Index, dubbed the IFEFSI. 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 other 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 2008 global financial crisis (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. FSIs 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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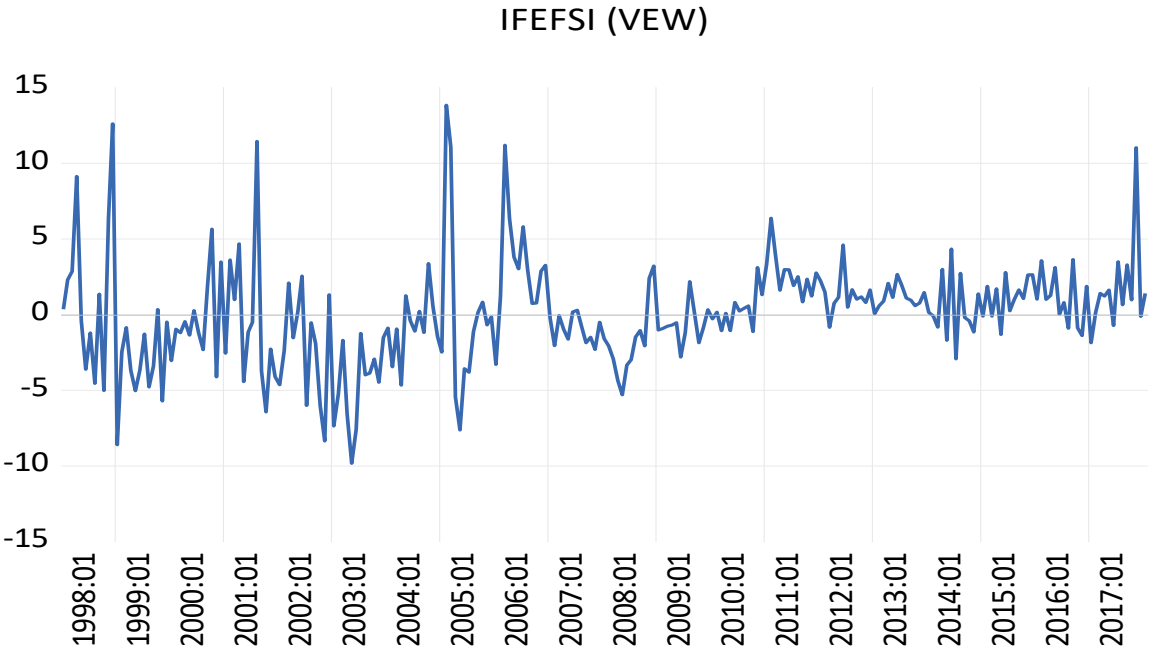
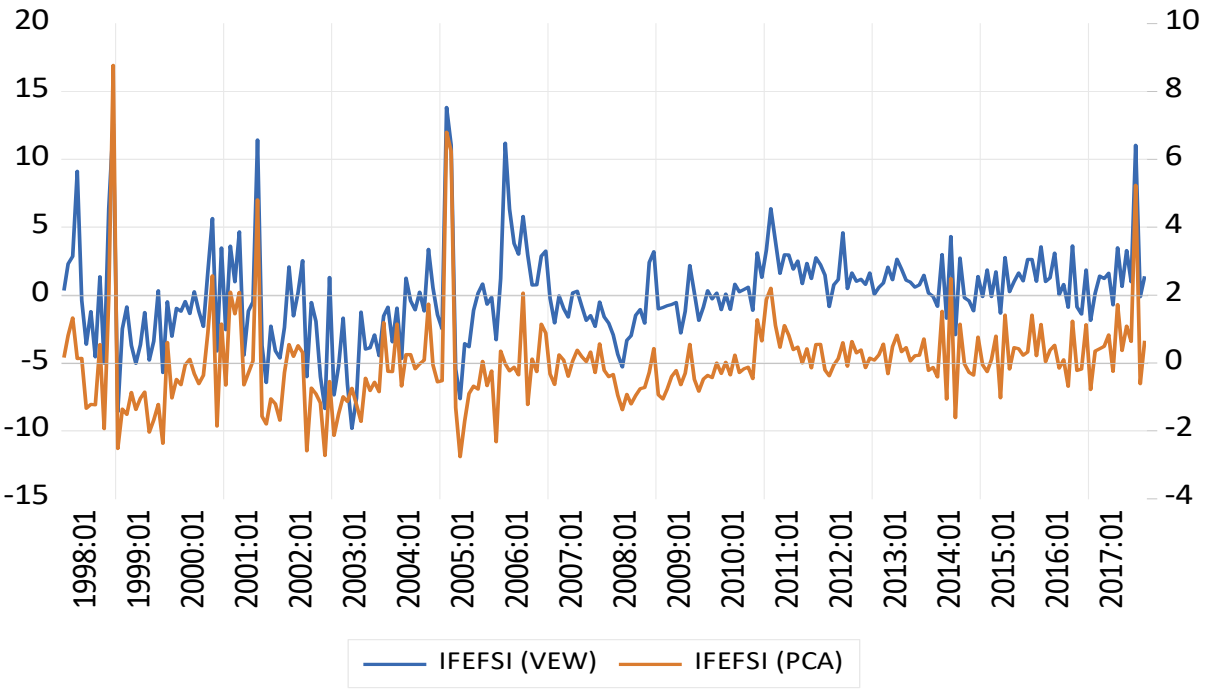
Figure 1: IFEFSI (variance equal weighting method)



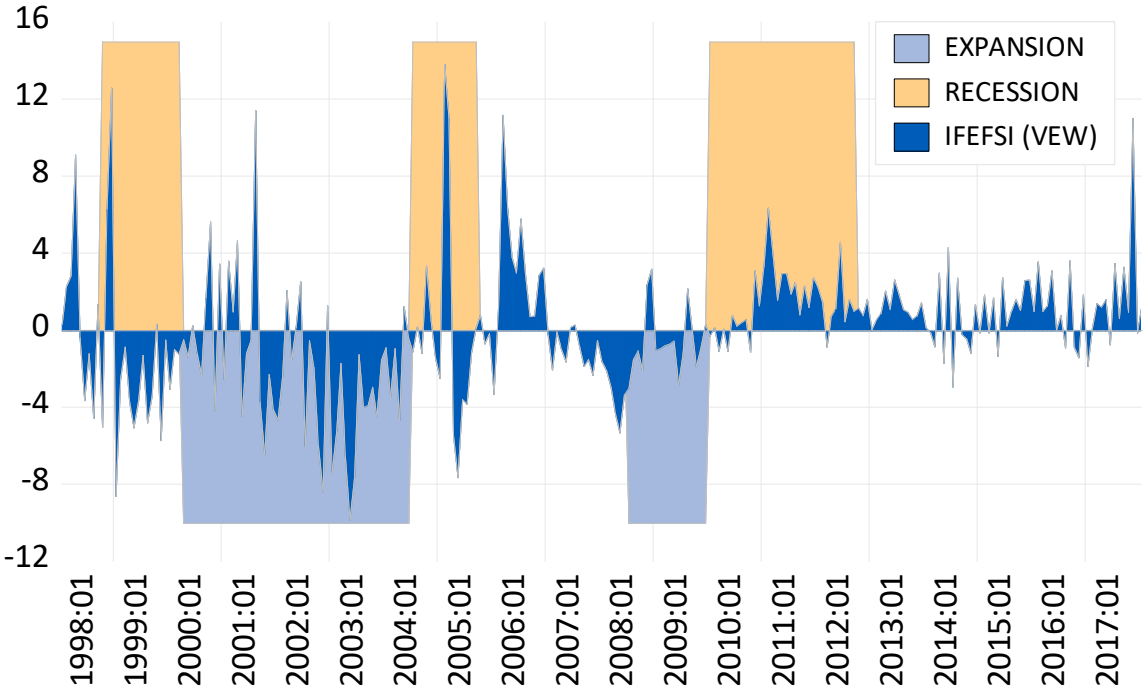
Source: Authors' calculation

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



Source: Authors' calculation

Figure 3: The IFEFSI and the business cycle from 1998 to 2018.



Source: Authors' calculations

Appendix A

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

where $e_{i,t}$ is the Lebanese pound per one dollar in period t;

σ_i 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;

$\sigma_r$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 the interbank rate in LBP and the Fed Fund rate in USD.

All changes in this model consist of 12 months' changes.

Appendix B

Table A.1 - Summary of selected Financial Stress Indexes listed chronologically

Authors	Year	Country	Aggregation Method/ Frequency	Indicators
Illing and Liu	2003	Canada	Credit weighting Daily	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 Yearly	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 Daily	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 Daily	see Illing and Liu (2003)
Misina and Tkacz	2008	Canada	see Illing and Liu (2006) Quarterly	see Illing and Liu (2006)
Cardarelli et al.	2009	17 developed countries[12]	Equal weighting Monthly	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[13]	Equal weighting Monthly	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 Monthly	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

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

[13] 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

				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
Central Bank of the Republic of Turkey	2009	Turkey	Not available Monthly	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[14]	Equal weighting Monthly	see Cardarelli et al. (2009)
Kliesen and Smith	2010	US	PCA Daily	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

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

				index 16- Vanguard financial exchange-traded fund 17- Merrill Lynch bond market volatility index 18- Chicago Board Options Exchange Market volatility index
Yiu et al.	2010	Hong Kong	Equal weighting Monthly	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 Daily	1- Exchange rate volatility 2- TED spread 3- Stock market volatility 4- Covered bonds-government bond spread
Slingenberg and De Haan	2011	13 OECD countries[15]	Equal weighting Monthly	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 Daily	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

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

Hollo et al.	2012	Euro Area	Equal weighting for indicators and time varying correlations for sub-indexes Weekly	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 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) Monthly	see Balakrishnan et al. (2009)
Tng et al.	2012	5 ASEAN countries[16]	Credit weighting Yearly	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[17]	PCA Monthly	1- Banking sector fragility index (based on assets and liabilities) 2- Stock market volatility 3- Exchange market pressure index (combing changes in exchange rate,

[16] 5 members of the Association of South East Asian Nations (ASEAN): Indonesia, Philippines, Malaysia, Singapore, and Thailand

[17] Bulgaria, the Czech Republic, Hungary, Poland, and Russia

				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 Monthly	1- Default probability of the banking sector 2- Beta of Stock Market 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 Daily-Monthly- Quarterly	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
Duca and Peltonen	2013	28 emerging and advanced economies[18]	Equal weighting Quarterly	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
Ekinci	2013	Turkey	Equal weighting Daily	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[19]	see Cardarelli et al. (2009) Quarterly	see Cardarelli et al. (2009)
Christensen and Li	2014	13 OECD countries[20]	see Cardarelli et al. (2009) Quarterly	see Cardarelli et al. (2009)
Zigraiova and Jakubik	2015	14 developing and advanced countries[21]	Market equal weighting Quarterly	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

[18] 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

[19] Canada, Germany, Japan, United Kingdom, United States, France and Italy

[20] Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom and United States

[21] Argentina, Czech Republic, Euro Area, Hungary, Japan, Korea, Mexico, Russia, Sweden, Switzerland, Thailand, Turkey, UK, and United States

				(for some countries, the yield on long term government bonds is used instead)
Dahalan et al.	2016	Malaysia	PCA Monthly	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[22]	Dynamic factor model Monthly	1- Banking sector returns volatility 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- Ratio of short term external debt to GDP 5- Sovereign risk (using contingent claim analysis)
Magkonis and Tsopanakis	2016	G5 countries[23]	see Cardarelli et al. (2009) Quarterly	see Cardarelli et al. (2009)
Aboura and Roye	2017	France	Dynamic factor model Daily-Monthly- Quarterly	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

[22] Indonesia, South Korea, Malaysia, Philippines, and Thailand
[23] Canada, Germany, Japan, United Kingdom, and United Stated

				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[24]	see Hollo et al. (2012) Monthly	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

[24] 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*

Figure A.1 Time plots of the normalized indicators for the banking sector

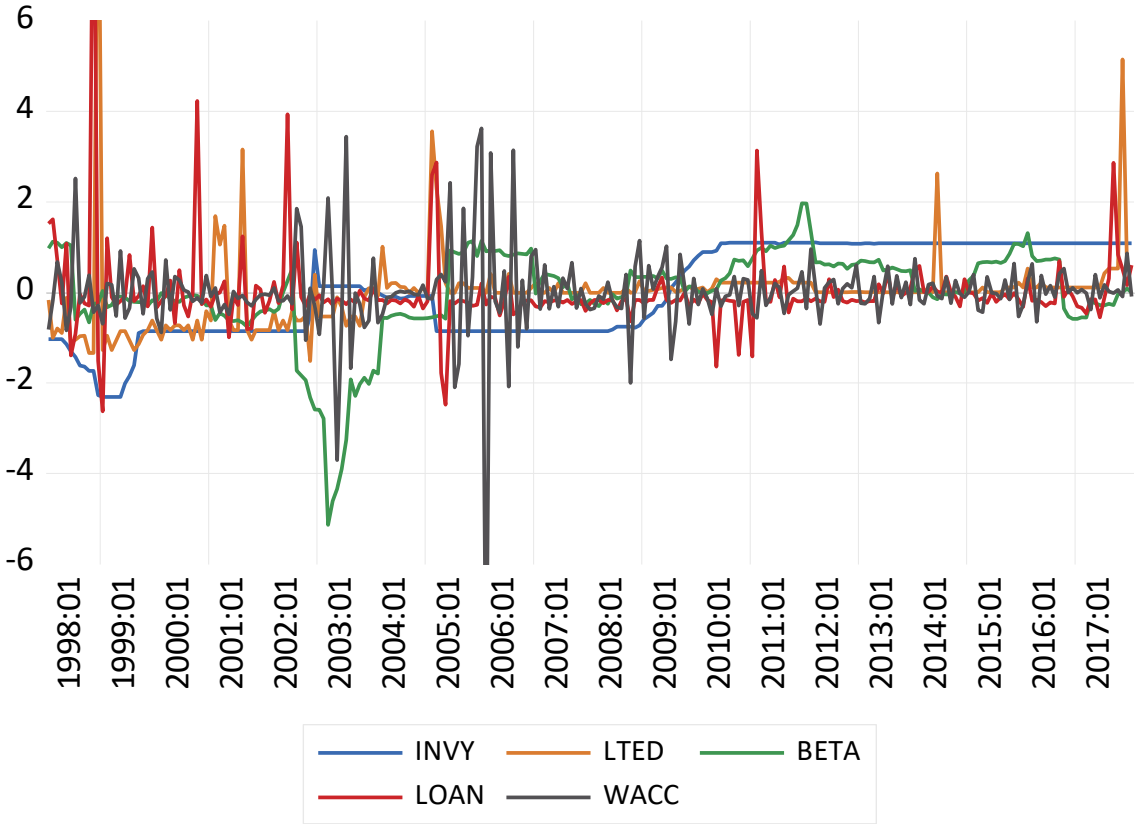


Figure A.2 Time plots of the normalized indicators for the equity market

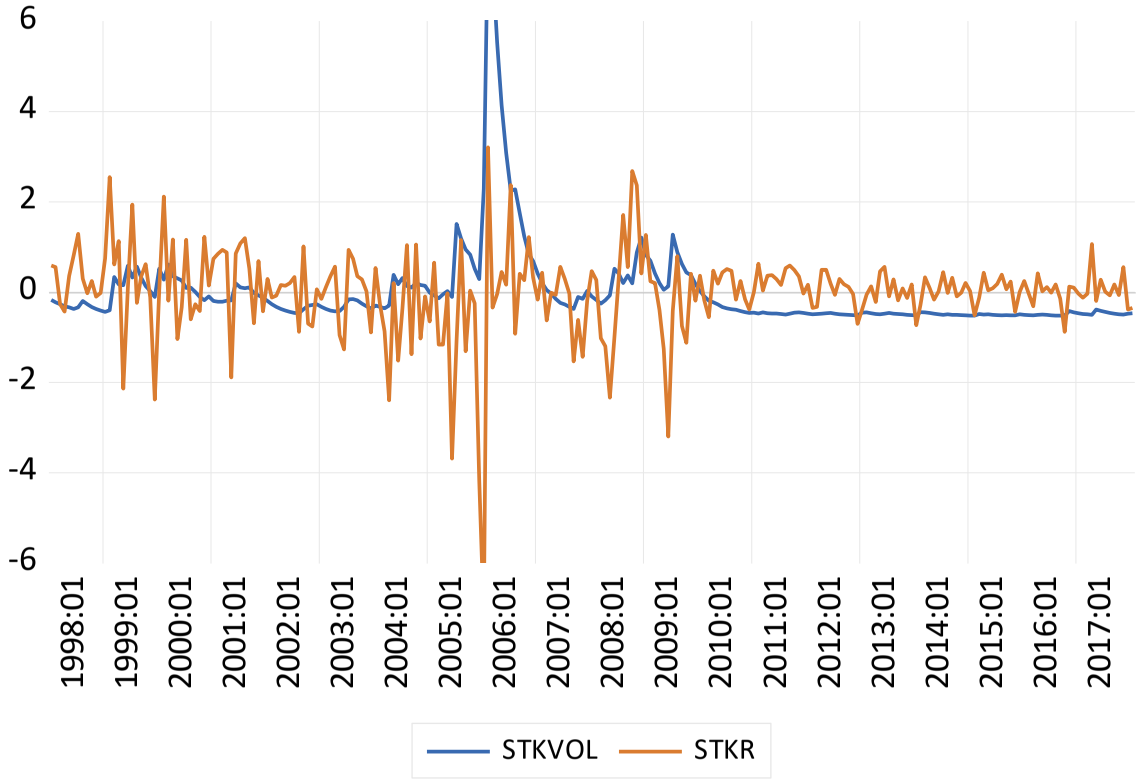
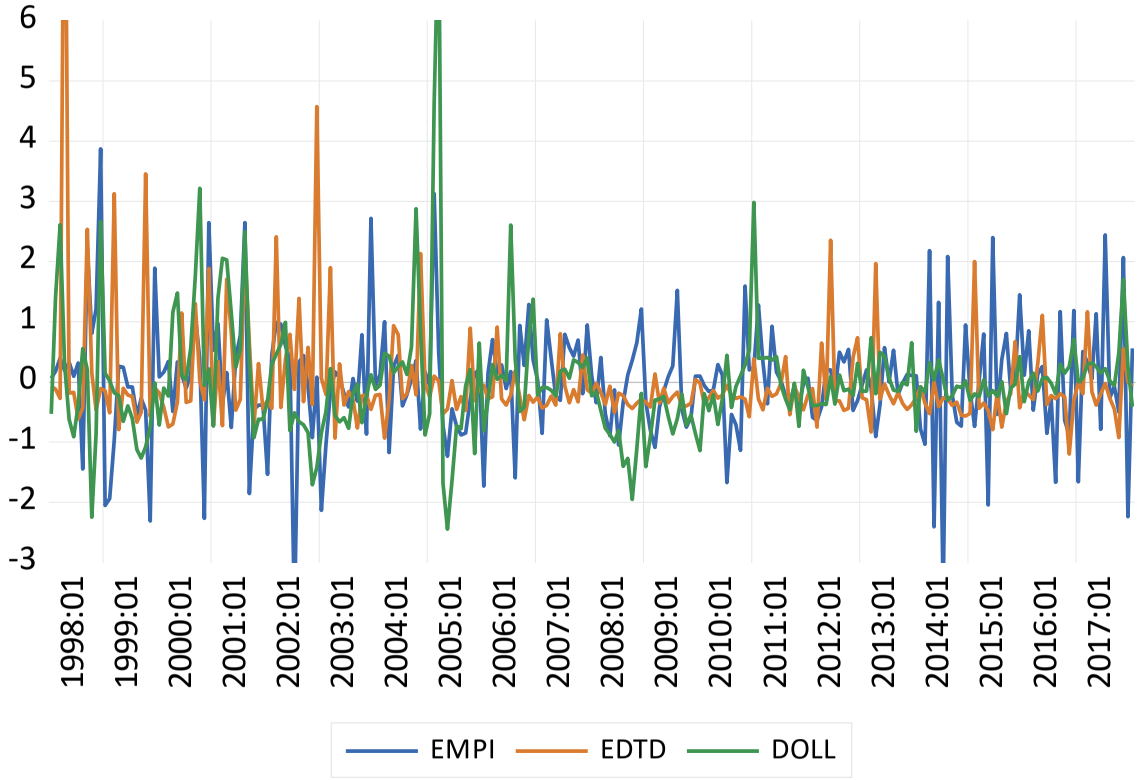


Figure A.3 Time plots of the normalized indicators for the foreign exchange and other markets



Appendix C

June 1998 Fitch downgrade (FC and LC)

June 1999 Fitch downgrade (LC)

February 2001 Fitch downgrade (FC and LC)

July 2001 Moody's downgrade (FC and LC)

September 2001 Fitch downgrade (FC and LC)

March 2005 Moody's downgrade (FC)

April 2009 Moody's upgrade (FC and LC)

March 2010 Fitch upgrade (FC and LC)

April 2010 Moody's upgrade (FC and LC)

November 2013 S&P downgrade (FC and LC)

December 2014 Moody's downgrade (FC and LC)

July 2016 Fitch downgrade (FC and LC)

August 2017 Moody's downgrade (FC and LC)