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The Impact of Variable Interactions on Lebanese Banks Fragility

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Abstract

This paper aimed at studying the development of bank fragility in Lebanon over the period 1990-2013. Using the Z-score measure, we find significant improvement of bank stability over the studied period. We also detect the impact of several internal and external factors on Z-score and find that bank size, liquidity, and market concentration boost bank stability. Conversely, higher net interest margin, deposit growth, and inefficiency increase insolvency risk. We extend our analysis and test the impact of variable interactions on Z-score and show that the common impact of many variables totally differs from the impact of those variables separately. This finding stresses the importance of looking beyond the influence of each factor individually and considering the impact of interaction among variables on bank fragility.

Keywords: insolvency risk, bank fragility, Z-score

1. Introduction

Over the past twenty five years, the Lebanese banking sector has undergone substantial changes, which considerably altered its landscape. This was manifested by large cross-border expansion, implementing more efficient organisational structures, developing IT infrastructures, improving disclosure and transparency standards, adopting more advanced risk management systems, developing governance frameworks, introducing greater variety of financial products, and better exploitation of scale and scope economies. This was coupled with the implementation of reform processes conducted by the regulatory and supervisory authorities, such as encouraging insolvent banks to merge with larger healthier ones, adopting tighter regulatory and supervisory standards, in addition to implementing the international solvency and liquidity norms. These reforms aimed to increase the efficiency and productivity of the banking sector, increase its competitiveness, and achieve a more stable operational environment. Moreover, the Lebanese banking system has witnessed a gradual decrease in the number of banks due to a wave of bank mergers and acquisitions and a gradual exit of foreign banks, which contributed to a significant increase in concentration. Consequently, the market share of the largest 3 banks increased from 21.6% in 1990 to 40.9% by the end of 2014, the market share of the largest 5 banks increased from 31.2% to 56.7%, and the market share of the largest 10 banks from 51.6% to 82.4%.

This paper addresses the impact of the above developments on the fragility of Lebanese banks using the Z-score indicator, in addition to detecting the factors affecting this fragility. Firstly, we find a significant improvement of bank stability over the studied period. Secondly, by detecting the impact of several bank-specific and external factors on Z-score, we find that larger size, higher liquidity, and higher market concentration improve bank stability. Conversely, we find that net interest margin (as a possible indication of pricing power), higher deposit growth, and poor cost efficiency increase insolvency risk. Thirdly, we test the impact of the interaction among all used control variables on Z-score. To our best knowledge, this is the first study that examined the combined impact of all possible pairs of control variables on bank fragility measure. In this regard, we find that the common impact of some variables totally differs from the impact of those variables separately, which reveals the importance of factor interactions on bank fragility and shows that focusing on the impact of factors individually is not sufficient to understand how bank fragility is determined.

The paper proceeds as follows. In Section 2 we present an overview of the regulatory and operational developments in the Lebanese banking system over the past twenty five years. An overview of the related literature is presented in section 3. The empirical methodology is illustrated in Section 4. We present and explain the data in Section 5. The empirical results are presented and analysed in section 6. Finally, the general

conclusions of the paper and the policy recommendations are presented in section 7.

2. Regulatory and Operational Developments in the Lebanese Banking Sector

Prior to the civil war (1975-1990), the Lebanese banking sector was the most advanced banking sector in the MENA region, and represented the region's banking hub. But the 15-year war has negatively affected its development, growth, and performance. Particularly, the sharp depreciation of the local currency (the Lebanese Pound) between late 1980s and early 1990s caused massive withdrawals of deposits from the Lebanese banks, which resulted in a large decline in their activities and an enormous dollarisation of assets and liabilities. Moreover, the decline of the regulatory and supervisory control during the 1980s resulted in a number of insolvent, underperforming, and unstable banks. For instance, the banking sector average equity-to-asset ratios during the years 1990, 1991 and 1992 recorded 1.38%, 1.66% and 1.94% successively, and the provisions for doubtful loans-to-gross loan ratios reached 33.41%, 27.46% and 24% successively.

To avoid the emergence of a banking crisis, the central bank of Lebanon decided to restructure the banking system and push banks to recapitalise. Many efforts were undertaken in this regard. Firstly, a law was passed in November 1991 aimed at reforming the banking sector and focused mainly on: (1) giving the banks that suffered losses of more than one quarter of their capital, one year to recapitalise otherwise they would have been delisted from the list of approved banks; and (2) giving the Higher Banking Committee the authority to liquidate insecure banks. In January 1992, another law was passed to facilitate bank mergers and acquisitions and offering incentives for merged banks. Vis-à-vis this law, the central bank of Lebanon issued directives to push banks towards more consolidations such as tighter capital requirements and branch opening restrictions. As mentioned above, this has participated in an increase in concentration, which raised concerns that a highly concentrated banking system dominated by few large banks, may exhibit a too-big-to-fail problem encouraging large banks to increase their risk exposure.

In 1993, all banks operating in Lebanon became subject to Basel I capital adequacy standards and were required to hold a minimum of 8% of risk-adjusted capital. By the end of 2000, these minimum capital requirements were increased to 10%, and to 12% by the end of 2001. In April 1, 2006, the central bank of Lebanon requested implementing the Basel II Capital Adequacy Accord by all banks operating in Lebanon in a progressive manner, in order to hold the minimum solvency ratio according to the new Accord as of January 1, 2008. In compliance with Basel III Accord, banks operating in Lebanon are preparing to fully meet the new minimum capital requirements as follows. Banks were required to hold a Tier 1 Common Equity ratio of 5% by the end of 2012 and 8% by the end of 2015; a Tier 1 Equity ratio of 8% at end 2012 and 10% at end 2015; a Total Capital ratio of 10% at end 2012 and 12% at end 2015. These ratios include the "Capital Conservation Buffer" that must reach 2.5% by the end of 2015.

Today, the banking sector in Lebanon is one of the most dynamic regional banking sectors, and proved to be one of the most resilient banking sectors worldwide during the 2008 international financial crises and remained very attractive to financial flows as evidenced by the high growth rate of deposits. This rate that reached 7.08% in 2006, recorded 11.71% in 2007, 15.06% in 2008, 22.24% in 2009, and 11.52% in 2010. Finally, we note that the consolidated assets of the Lebanese banking sector increased from Lebanese Pound 5.03 trillion in 1990 ($8.3 billion) to Lebanese Pound 280 trillion in 2015 ($186 billion). In relative terms, the size of the Lebanese banking sector (in terms of assets) increased from 2.55 times the country's GDP in 1990 to 3.60 times in 2015.

3. Literature Review: The Main Determinants of Bank Fragility

A large body of literature implemented the Z-score as an indicator to measure bank fragility/stability. Interestingly, those works widely diverge in their objectives for using Z-score but converge in the sense of trying to detect the impact of certain "factors", "events", or even "circumstances" on bank probability of insolvency. Those could be: regulation or deregulation, economic or financial crises, credit booms, changes in market concentration or competition, bank consolidation, cross-border expansion, business diversification, financial innovation, developments in corporate governance, etc... In the following we present an overview of the literature that examined bank fragility using Z-score, with different objectives. Specifically, we extract the main determinants of bank fragility, in other words, the major factors that shape bank Z-score.

One of the main concerns in banking is the impact of market structure on bank stability. In this regards, Boyd and De Nicoló (2005) argue that concentration increases market power, which allows banks to raise interest rates. Along these lines, the authors reason that higher interest rates may encourage firms to take greater risk, which results in a higher probability that loans turn non-performing. Ivičić et al. (2008) study the effect of some macro variables on bank fragility in Central and Eastern European countries where the financial system is dominated by commercial banks. The authors provide empirical evidence that bank stability, measured by Z-score, decreases

with credit growth, inflation and banking sector concentration. Fu et al. (2014) examine the impact of bank competition, concentration and regulation on bank fragility in 14 Asia Pacific economies from 2003 to 2010, as measured by Z-score. Their findings show that greater concentration and stronger deposit insurance schemes contribute to greater bank fragility.

Schaeck and Cihák (2008) analysed the link between competition, efficiency, and bank soundness. Using a data set for 10 European countries and the United States during 1995-2005, and covering more than 3,600 European banks and more than 8,900 U.S. banks. Their findings indicate that increased competition increases bank soundness. Amidu and Wolfe (2013) explore how competition affects diversification and stability using a sample of 978 banks in 55 emerging and developing countries over the period 2000-2007. They used *Z*-score as an indicator of bank fragility and found that competition increases bank stability, and the latter increases with higher profitability and capitalisation levels, and decreases with unstable earnings. This supports the view that banks in more competitive banking systems hold higher capital levels in order to compensate for the potential higher risks they undertake (Berger et al., 2009).

Using a sample of commercial banks from 12 Asian countries during 2001-2007, Soedarmono et al. (2011) found that higher market power in the banking market results in higher instability. Moreover, they found that higher economic growth contributes to neutralising higher risk taking and higher instability in less competitive markets. Beck et al. (2013) show a positive relationship between banks' market power, as measured by the Lerner index, and banks' stability, as measured by the Z-score. Moreover, the authors show that an increase in competition will have a larger impact on banks' risk taking incentives in countries with stricter activity restrictions, more homogenous market structures, more generous deposit insurance and more effective systems of credit information sharing.

Yeyati and Micco (2007) exploit a bank-level database for 8 Latin American countries to examine how competition, concentration and internationalization influence banking stability. They find that increased concentration has no influence on bank insolvency risk, whereas foreign penetration induced lower levels of risk. Berger et al. (2015) investigate the effects of bank internationalization on risk-taking. Using a sample of 15,988 U.S. banks over the period 1986-2010, they find that the *Z*-score of U.S. banks that engage in foreign activities is lower than that of their purely domestic peers. The authors state that this result is consistent with the market-risk hypothesis, and suggests that the additional local market risks associated with international expansion outweigh the benefits of geographical diversification.

Beck et al. (2009) studied the stability of German banks with different ownership structures over the period 1995-2007. By employing Z-score, the authors found evidence for the too-big-to-fail phenomenon, as larger privately-owned banks hold less risk-weighted capital than their smaller peers, thus moving closer to insolvency. Bhagat et al. (2015) investigated the link between size and risk-taking among financial institutions over the period 2002-2012. They found a positive correlation between size and risk-taking, and stated that financial firms engage in excessive risk-taking mainly through increased leverage.

Demirgüç-Kunt and Detragiache (2009) test whether the compliance with Basel Core Principles for effective banking supervision results in safer banks. Using the Z-score of over 3,000 banks from 86 countries, the authors do not find that better compliance with Basel Core Principles is associated with lower bank risk.

Several studies have tried to discover the impact of governance practices (at micro and macro levels) on bank stability. In this regard, Setiyono and Tarazi (2014) examine the relationship between disclosure and the risk-taking behaviour of a sample of 209 publicly-listed Asian commercial banks between 2004 and 2010, and find that better disclosure is associated with lower default risk. Chen et al. (2015) address the impact of corruption on risk-taking behaviour of more than 1,200 banks in 35 emerging markets between 2000 and 2012. Their empirical results show that more severe corruption increases the risk-taking of banks.

Finally, the impact of financial innovation on bank fragility has been examined by Beck et al. (2014) who used a sample of more than 2,000 banks from 32 countries over the period 1996-2006, and found that higher level of financial innovation is associated with higher bank risk-taking and fragility, especially among banks with smaller market shares and lower loan-to-asset ratio. Also Kühnhausen (2014) evaluated the impact of innovative activities on a sample of U.S. banks between 1990 and 2002, and showed that larger degree of innovation affects negatively firm stability.

4. Empirical Methodology

4.1 Measuring Bank Fragility

The Z-score technique has captured the attention of academics and practitioners as it provides a thorough

assessment of bank "fragility risk", and is based on computing a "risk indicator" for a bank or for the entire banking sector. Z-score is in fact used as a measure of bank stability and indicates the "distance from default", by combining accounting measures of profitability, leverage and volatility. Specifically, Z-score indicates the number of standard deviation that a bank's return has to fall below its expected value before equity is depleted and the bank is insolvent. Z-score technique is an improvement of previous measures, such as the ratio of NPL, loan spread, interest margin, and capital adequacy, particularly in cross-country studies due to differences in market structure, risk-free interest rates and operating costs, and capital regulation across countries (Demirgüç-Kunt & Detragiache, 2009). Besides, despite the fact that Z-score is based on accounting data, it has the advantage that it can be used for institutions where more advanced market data are not available.

To account for Lebanese banks fragility risk, we use the Z-score measure based on ROA. This measure indicates the number of standard deviations that a bank's ROA has to fall below its expected value before equity is completely exhausted. A higher (lower) Z-score is an indication of a decrease (increase) in bank insolvency risk. Z-score is computed as follows:

$$Z - score_{i,t} = \frac{ROA_{i,t} + E/A_{i,t}}{\sigma ROA_{i,t}} \quad (1)$$

where $ROA_{i,t}$ is the return on average assets, $E/A_{i,t}$ is the equity-to-asset ratio, and $\sigma ROA_{i,t}$ is the standard deviation of $ROA_{i,t}$.

Three variables are necessary to calculate the fragility indicator Z-score: (1) bank equity, (2) bank net profits, and (3) bank total assets. Equity-to-total assets ratio is exploited to capture the level of bank capitalisation – which is essentially a measure of leverage – where leverage ratio can be a tool to discipline bank moral hazard (Blum, 2008). Following Agoraki et al. (2011), $\sigma ROA_{i,t}$ is calculated from the values of return on average assets taken from period *t* to *t*-2 (i.e. a three-period rolling window).

4.2 Control Variables: Factors Affecting Bank Fragility

After calculating the fragility indicator for the entire Lebanese banking sector, we will study the link between insolvency risk and a number of relevant control variables extracted from the previously cited literature. Generally, these variables fall into two categories: bank-specific (internal) variables and external variables.

Firstly, the bank-specific explanatory variables are the following. We follow Berger et al. (2015), Setiyono and Tarazi (2014) and Chen et al. (2015) to include the size of the bank as an explanatory factor for bank stability, which will be measured by the natural logarithm of total assets (*SIZE*). This variable could identify the presence (or the absence) of economies of scale and/or scope in the banking industry. On the other hand, it may reveal the existence of the "too-big-to-fail" hypothesis (Mishkin, 2006).

Most empirical studies exploit profitability (approximated by ROA) as an explanatory variable for bank stability. Nevertheless, we will detect the impact of profitability using the net interest margin (*NIM*) since it may reveal the market power of banks.

The impact of tightening capital requirements on Lebanese banks over the past two decades on bank stability will be examined. Almost all empirical studies use the equity-to-asset ratio to detect for the impact of leverage, but we follow Setiyono and Tarazi (2014) and adopt bank capital adequacy ratio (Note 1) as a proxy for capitalisation or leverage (*BIS*). We note that Lebanese banks capital adequacy ratio for the period 1993-2009 was reported according to Basel I Accord, and according to Basel II Accord for the period 2010-2013.

Bank liquidity may support bank resilience. Therefore, following Jayaraman and Kothari (2013) and Chen et al. (2015), we test the impact of this variable on bank stability, and we approximate it by the ratio of liquid assets-to-total assets (*LIQ*).

The Lebanese banking secrecy law, coupled with the resilience and soundness of the banking sector, allowed the Lebanese banking sector to receive continuous local and regional deposit inflows, in addition to financial inflows from the large Lebanese Diaspora. These inflows may help banks boost their liquidity on one hand, and allow them to expand their lending activities on the other. The impact of this variable on bank stability will be analysed and represented by the annual percentage change in customer deposits (*DEP*).

Bank technical efficiency could have a direct impact on its stability where more efficient banks are expected to incur lower risks (Berger & De Young, 1997). Therefore, we will detect the impact of this variable on Z-score, and we approximate it by the cost-to-income ratio (*CI*).

Credit risk is assumed to undermine bank stability since it could be a major determinant of both bank risk and capitalisation. Following Schaeck and Cihák (2008), Laeven and Levine (2009), and Jayaraman and Kothari (2013), we control for the influence of the deterioration of asset quality on bank stability by the ratio of loan loss

provisions-to-total loans (*LLP*).

Secondly, to detect the impact of changes in operational and economic conditions on Z-score, we exploit the following variables. To control for the impact of economic conditions on bank fragility, we base on and Amidu and Wolfe (2013) and implement the annual real GDP growth rate (*GDPG*) and the inflation rate (*INFL*).

As mentioned above, the Lebanese banking sector witnessed a trend of bank consolidation over the past twenty five years, which has resulted in a considerable increase in concentration. This phenomenon may increase bank market power and encourage banks to take more risk. Therefore, to detect whether the banking sector in Lebanon is dominated by the "competition-fragility" or the "competition-stability" views, the impact of banking concentration will also be analysed. We follow Yeyati and Micco (2007) and represent this variable by the asset market share of the largest five banks (*CONC5*).

Finally, Lebanese banks operate in very politically unstable region (Note 2). Therefore, to control for the impact of local and regional political shocks that are likely to deteriorate the quality of banks' assets, we exploit a dummy variable that takes the value of 1 for shocks, 0 otherwise (*SHOCKS*) (Note 3).

The equation linking bank fragility to the set of explanatory variables is as follows:

$$Z - score_{i,t} = \beta_0 + \beta_1 NIM_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 DEP_{i,t} + \beta_4 LIQ_{i,t} + \beta_5 CI_{i,t} + \beta_6 BIS_{i,t} + \beta_7 LLP_{i,t} + \beta_8 GDPG_t + \beta_9 INFL_t + \beta_{10} CONC5_t + \beta_{11} SHOCKS_t + \varepsilon \quad (2)$$

For the calculation of all variables, see Appendix A.

5. Data

To estimate banks fragility indicator, we use a panel data set for the Lebanese commercial banks between 1990 and 2013, i.e. a 24-year period. Thirty eight commercial banks operating in Lebanon during that period are included in our data set. This number represents about 70% of the bank population in Lebanon. We note that our selection of banks was constrained to those having at least 10 years of data. Moreover, following Schaeck and Cihák (2008) and Chen et al. (2015), extreme values (lying in the 1st or 99th percentile of the distribution) have been dropped.

The source of all bank data is BilanBanques. The macroeconomic variables (GDP growth and inflation rate) were extracted from the IMF database. Table 1 presents summary statistics for some of the explanatory variables, and Table 2 contains the correlation matrix of all explanatory variables.

Table 1. Descriptive statistics of exploited variables

	Mean	Median	Max	Min	SD	CV	Obs.
			1992				
IRS	2.99	2.64	14.00	-2.11	2.84	0.95	34
DEP	110.28	111.14	237.56	4.54	36.04	0.33	35
LIQ	61.17	63.88	84.13	11.46	15.49	0.25	35
CI	85.30	94.72	100.00	27.20	18.71	0.22	35
BIS	7.58	6.43	35.81	0.10	7.34	0.97	35
LLP	16.75	14.62	60.00	0.00	14.21	0.85	34
			2002				
IRS	2.77	2.59	11.92	1.36	1.80	0.65	31
DEP	14.45	8.09	52.28	-6.66	15.31	1.06	31
LIQ	67.08	67.36	83.00	41.80	10.31	0.15	31
CI	70.77	69.32	102.10	39.25	18.57	0.26	31
BIS	23.08	19.22	44.22	7.80	9.70	0.42	31
LLP	17.34	15.74	37.06	3.66	8.27	0.48	31
			2013				
IRS	1.96	1.70	6.14	1.04	0.97	0.49	29
DEP	8.10	9.88	20.69	-14.04	7.90	0.97	29
LIQ	63.11	65.34	82.69	0.00	15.67	0.25	30
CI	57.16	56.04	95.52	0.00	18.90	0.33	29
BIS	18.80	14.26	149.63	5.77	24.93	1.33	30
LLP	9.11	5.51	40.28	1.04	8.58	0.94	30

Note. Max: maximum. Min: minimum. SD: standard deviation. CV: coefficient of variation. Obs.: number of observations.

Table 2. Correlation matrix of exploited variables

	IRS	SIZE	DEP	LIQ	CI	BIS	LLP	GDPG	INFL	CONC5	SHOCKS
NIM	1										
SIZE	-0.46	1									
DEP	0.04	-0.05	1								
LIQ	0.00	0.19	-0.01	1							
CI	-0.09	-0.36	0.11	-0.28	1						
BIS	0.27	-0.27	0.07	0.24	-0.07	1					
LLP	0.02	-0.20	-0.05	0.10	0.21	0.25	1				
GDPG	0.12	-0.08	-0.01	0.06	-0.06	0.09	0.02	1			
INFL	0.07	-0.27	0.01	-0.09	0.10	-0.13	-0.05	0.06	1		
CONC5	-0.41	0.52	-0.04	0.23	-0.20	0.12	0.02	0.14	-0.35	1	
SHOCKS	-0.01	0.12	0.05	0.03	-0.07	-0.07	-0.03	-0.37	-0.14	0.21	1

6. Empirical Results

6.1 Evolution of Fragility Indicators

Table 3 shows the development of Lebanese commercial banks average Z-score between 1992 and 2013, with the median, maximum and minimum values, in addition to their standard deviations, coefficient of variations, and the number of observations (banks) used to compute these values (Note 4).

Obviously, the average value of Z-score has developed significantly over the studied period, from 28.80 in 1992 to 150.94 in 2013. This reflects a significant increase in the stability of Lebanese banks as a result of the central bank's initiatives and efforts, such as encouraging bank consolidations, boosting liquidity and solvency by enforcing the adoption of Basel I, II and III capital and liquidity standards. This was also accompanied by banks' efforts to adopt more efficient structures, improve risk management frameworks, boost provisions and reserves, and adopt advanced governance models.

Table 3. Evolution of Lebanese commercial banks Z-score

Year	Mean	Median	Max	Min	SD	CV	Obs.
1992	28.80	10.61	262.74	3.07	55.01	1.91	24
1993	95.80	17.26	1399.26	1.12	268.69	2.80	28
1994	30.86	9.15	358.37	0.94	69.79	2.26	33
1995	40.62	14.58	520.92	4.68	94.00	2.31	36
1996	28.80	18.44	171.46	5.62	31.33	1.09	36
1997	25.99	16.15	164.03	5.07	27.42	1.05	38
1998	29.22	17.80	171.33	5.82	31.23	1.07	38
1999	65.83	23.29	1156.06	5.20	192.76	2.93	35
2000	43.23	31.05	265.81	2.96	50.91	1.18	34
2001	62.81	37.05	655.25	5.02	111.17	1.77	32
2002	49.36	42.48	127.87	7.11	32.45	0.66	31
2003	73.81	54.48	223.28	3.30	62.15	0.84	31
2004	131.40	46.83	2178.64	0.52	377.42	2.87	32
2005	142.08	56.57	2561.89	3.28	443.93	3.12	32
2006	110.12	63.96	996.16	5.58	176.79	1.61	31
2007	153.92	75.74	1066.62	9.03	241.21	1.57	31
2008	142.93	72.60	1227.44	10.45	236.09	1.65	31
2009	96.89	60.24	460.61	8.16	100.19	1.03	30
2010	107.61	75.30	428.07	9.39	99.06	0.92	30
2011	103.86	71.40	374.35	10.12	90.36	0.87	28
2012	198.16	73.87	3041.60	14.49	555.39	2.80	29
2013	150.94	89.00	585.66	0.70	142.41	0.94	30

Note. Max: maximum. Min: minimum. SD: standard deviation. CV: coefficient of variation. Obs.: number of observations.

For deeper analysis and understanding of the above computed fragility indicators, we move forward and

compare the yearly differences of stability measures between the largest 10 banks (that control about 82% of the Lebanese banking sectors' assets and have considerable regional and international spread) and all other banks. The results are reported in Table 4. We observe a superior stability for the largest 10 banks, statistically significant at the 5% level in years 1997 and 2002, and at the 10% level in years 1996, 1998, 2003, 2010, and 2011. During the remaining years, the largest banks did not record statistically significant better or worse stability measures. Overall, these results contradict those of Beck et al. (2009) who found that larger German banks have higher insolvency risk than smaller ones. Moreover, our results somehow contradict the findings of Berger et al. (2015) who investigated the effects of U.S. bank internationalisation on risk-taking and found that *Z*-score of banks that engage in foreign activities is lower than that of their purely domestic peers. This could be due to the fact that larger and internationally spread Lebanese banks adopt conservative practices and do not reflect a "too-big-to-fail" behaviour, in addition to the particular scrutiny and higher regulatory requirements, as they are considered as *systemically important banks*.

Table 4. Comparing Z-score between banking groups

	Largest 10 banks				Other banks				
	Mean	SD	CV	Obs.	Mean	SD	CV	Obs.	Mean difference
1992	17.20	14.65	0.85	9	35.38	68.74	1.94	15	-18.18
1993	40.60	41.82	1.03	10	127.36	332.84	2.61	18	-86.77
1994	36.10	61.50	1.70	10	29.04	74.34	2.56	23	7.06
1995	52.64	78.84	1.50	10	37.15	100.44	2.70	26	15.49
1996	56.02	49.44	0.88	10	19.65	13.44	0.68	26	36.37*
1997	48.38	44.05	0.91	10	17.79	10.88	0.61	28	30.59**
1998	51.91	44.42	0.86	10	22.30	22.13	0.99	28	29.60*
1999	58.54	50.27	0.86	10	70.54	227.18	3.22	25	-12.01
2000	51.59	49.03	0.95	10	37.95	51.76	1.36	24	13.64
2001	56.12	30.49	0.54	10	62.78	133.58	2.13	22	-6.66
2002	68.61	31.79	0.46	10	40.71	29.68	0.73	21	27.89**
2003	111.90	77.37	0.69	10	58.42	48.27	0.83	21	53.48*
2004	94.67	66.31	0.70	10	149.11	455.35	3.05	22	-54.44
2005	101.39	48.02	0.47	10	162.82	537.11	3.30	22	-61.43
2006	83.19	62.17	0.75	10	117.27	212.07	1.81	21	-34.08
2007	94.57	48.65	0.51	10	179.60	289.94	1.61	21	-85.03
2008	207.39	364.95	1.76	10	117.12	146.65	1.25	21	90.27
2009	147.68	144.97	0.98	10	75.98	63.13	0.83	20	71.69
2010	178.48	131.93	0.74	10	77.64	62.42	0.80	20	100.84*
2011	140.48	108.17	0.77	10	83.50	74.46	0.89	18	56.98*
2012	427.15	929.49	2.18	10	87.07	100.37	1.15	19	340.08
2013	144.23	103.11	0.71	10	147.99	160.90	1.09	20	-3.76

Note. SD: standard deviation. CV: coefficient of variation. Obs.: number of observations. **, * denotes significant at the 5% level and 10% level respectively.

6.2 The Impact of Control Variables on Bank Fragility

After computing Z-scores in the previous section, we test the impact of the control variables presented in Section 4.2 on the fragility measures. Table 5 presents the estimation results of several combinations of explanatory variables. The choice between estimations based on Fixed Effects or Random Effects methods is based on the Hausman test.

Table 5. The impact of control variables on bank fragility (method: fixed effects)

	1	2	3	4	5	6
C	76.85	-457.55***	-201.00***	11.42	76.17	-500.83***
	(72.34)	(130.90)	(71.53)	(63.90)	(70.42)	(137.86)
NIM	-16.39***				-16.91***	
	(6.28)				(6.28)	
SIZE		38.09***				37.10***
		(8.68)				(8.74)
DEP	-0.32		-0.15	-0.43*		
	(0.24)		(0.24)	(0.23)		
LIQ	1.02		0.50	1.55*	0.99	0.95
	(0.98)		(0.96)	(0.92)	(1.07)	(0.95)
CI	-0.75**	-0.38		-0.57*	-0.64**	-0.37
	(0.35)	(0.35)		(0.32)	(0.32)	(0.35)
BIS	0.07	0.27		-0.04	0.07	0.21
	(0.40)	(0.40)		(0.39)	(0.39)	(0.40)
LLP	0.20	0.91	0.11			0.59
	(1.08)	(1.01)	(1.00)			(0.56)
GDPG	1.49	0.44		-0.58		0.28
	(2.42)	(2.22)		(2.24)		(2.23)
INLF			0.25		0.68	
			(1.95)		(1.99)	
CONC5			4.74***			
			(1.10)			
SHOCKS	28.75*		15.49		24.23	
	(17.26)		(15.89)		(16.03)	
Adjusted R^2	0.227	0.237	0.243	0.218	0.225	0.237
Observations	649	650	652	652	653	650
F-stat.	5.157	5.695	5.766	5.222	5.303	5.588
Prob(F-stat.)	0.000	0.000	0.000	0.000	0.000	0.000
Durbin-Watson stat.	2.02	2.02	2.01	2.01	2.01	2.02
			Hausman test			
χ^2 stat.	73.466	85.304	77.850	71.342	73.013	86.797
Prob(χ^2)	0.000	0.000	0.000	0.000	0.000	0.000

Note. Standard error in parentheses. ***, **, * denotes significant at the1%, 5% level and 10% level respectively.

The empirical results show that NIM has a negative and significant impact (at the 1% level) on Z-score, which suggests that higher NIM results in higher fragility. This may in fact show that banks with higher market power (shown by their ability to extract higher returns from their customers) tend to have higher risk appetite and are willing to take more risk, which may increase their fragility. Thus, our findings could be in line with Soedarmono et al. (2011) who found that higher market power lowers banks stability, but contradict Beck et al. (2013) who found a positive relationship between market power and bank stability. The results also show that larger Lebanese commercial banks have significantly higher stability than smaller ones, shown by the positive and significant impact (at the 1% level) of SIZE on Z-score. This is in line with the findings of Schaeck and Cihák (2008) on European banks, and may be due to the fact that larger banks have higher and/or more stable profitability than smaller banks. Moreover, the diversification ability, the adoption of more sophisticated risk management techniques and more advanced business models, allow larger banks to enjoy higher stability. Conversely, Chen at al. (2015) and Bhagat et al. (2015) found a negative and significant impact of financial firm size on stability.

Deposit growth has a negative impact (significant at 10% in one model) on bank stability. Thus, an increase in deposits (which involves paying interest to depositors), with very limited investment and lending opportunities that the Lebanese market witnesses, may push banks to grant more risky loans, and that in turn increases credit risk and consequently, bank fragility. Our empirical results show that bank liquidity seems to have some positive impact (significant at the 10% level in one model) on stability, and higher liquidity levels lower banks fragility.

This is in line with the findings of Chen et al. (2015) but contradicts Jayaraman and Kothari (2013) who state that more liquid banks are associated with more risk-taking.

Bank efficiency has a positive and direct impact on bank fragility. This is shown by the negative and significant impact of CI on Z-score, which is in line with Soedarmono et al. (2011) and Chen et al. (2015). This may give evidence that inefficient banks that suffer from cost inefficiency are more fragile. Bank solvency (BIS) does not seem to improve or deteriorate bank stability, since this variable captures a negative sign (insignificant) in some models and positive sign (also insignificant) in other ones. This fact does not allow drawing any meaningful conclusion regarding the relationship between solvency and stability. We could link this result to Demirgüç-Kunt and Detragiache (2009) work, who found that complying with Basel Core Principles does not add value to bank Z-score.

LLP records a positive impact (statistically insignificant though) on Z-score. This may suggest that building provisions to face mounting credit risk and the deterioration of credit quality may add little value to bank stability. We note that our findings contradict Jayaraman and Kothari (2013) who found a negative influence of LLP on bank Z-score and argue that riskier banks provide for more losses on their loan portfolio. The two macroeconomic variables (GDP growth and inflation rate) do not have a significant influence on Z-score, which may suggest that Lebanese bank fragility is not significantly affected by the normal macroeconomic conditions. This is in fact in line with the findings of Amidu and Wolfe (2013), but contradicts those of Yeyati and Micco (2007) and Chen et al. (2015) who found that economic growth reduces bank risk, and Setiyono and Tarazi (2014) who showed that both GDP growth and inflation had a negative impact on Z-score.

The concentration in the Lebanese banking sector seems to have some productive effect on bank stability, which is consistent with "competition-fragility" hypothesis. This result is consistent with Berger et al. (2009) who found that banks with a higher degree of market concentration have less overall risk exposure. Conversely, our results contradict Schaek and Čihák (2008) who found that increased competition increases bank soundness (Note 5). Our results could have several interpretations. Firstly, higher concentration may allow Lebanese banks to exercise oligopolistic behaviour, which permits them to obtain higher and/or more stable returns, and that in turn, lowers their fragility. Another interpretation is that higher concentration is not accompanied with the tendency to adopt riskier behaviour due to the firm prudential regulation implemented by the central bank and the supervisory authorities.

Finally, SHOCKS appears to have a positive impact on Z-score (significant at 10% in one model). This may give some evidence that following an economic and/or political shock, banks tend to boost their capital or adopt a more conservative behaviour, which lowers their fragility.

6.3 The Impact of the Interaction among the Control Variables on Bank Fragility

Bank stability/fragility may not be determined only by the above cited factors, but also (and maybe more importantly) by the interaction among them. The interaction (or the common effect) between variables may have a direct (positive or negative) and significant impact on the performance, solvency, efficiency, and riskiness of banks, and consequently their stability.

Several studies have examined the effect of the interaction between a key specific factor and several other factors on bank Z-score. For instance, Leaven and Levine (2009) studied the interaction between the ownership structure of banks on one hand, and capital requirements, capital stringency, activity restriction, and deposit insurance on the other. Beck et al. (2013) tested the interaction between bank market power and: the depth of information sharing, stock market turnover, capital stringency, deposit insurance coverage, multiple supervisors, external governance, activity restrictions, heterogeneity of revenues, and systemic stability. Kühnhausen (2014) studied the interaction of innovation with: bank size, bank profitability, and leverage. Beck et al. (2014) detected the impact of the interaction between financial innovation on one hand, and bank market share, bank revenue growth, and bank loan-asset ratio on the other. Finally, Setiyono and Tarazi (2014) examined the impact of the interaction between disclosure on one hand and several ownership structure measures and concentration on the other. Hence, we extend our analysis in this regard, but unlike the above studies we do not limit the interaction between one key variable and other variables, and we examine the interaction among all control variables used in this study, in order to find out how they act together to shape (boost or deteriorate) bank stability. We tested the common impact of all possible pairs (i.e. 2 variables at a time) and found significant impact of several pairs that allow us to draw very interesting results. Moreover, and in order to assure the persistency of the impact of these interactions, we present two different models that include each pair. These results are presented in Table 6 (Note 6).

The interaction between deposit growth and credit risk: we noticed from Table 5 that DEP had a negative

significant impact in one of the three presented models; conversely LLP had a positive and insignificant impact. The interaction between these two variables (DEP x LLP) captures a negative and even more significant impact than that recorded by DEP alone. Therefore, this result may show that a combination of high deposit growth (as a result of increase in deposit inflows) and an increase in credit risk will significantly deteriorate bank stability. Therefore the tendency of banks to attract more deposits and channel them into risky loans (with high rate of return to offset the increase in deposit cost), will have a devastating impact on bank stability.

The interaction between bank size and net interest margin (SIZE x NIM): size captured a positive and significant impact at the 1% level, whereas NIM captured a negative impact, also significant at 1% level. Therefore, these two variables have in fact two opposing effect and should (theoretically) cancel out each other. Nevertheless, the interaction between these two variables is negative and statistically significant. This shows that the negative impact of NIM dominates the positive impact of SIZE. The interpretation of this phenomenon is that large banks that exercise some pricing power or engage in risky businesses with high returns will end up facing higher fragility. This suggests that those banks cannot rely on their diversifications abilities and advanced risk management frameworks to engage in risky activities, as this will result in higher fragility.

The interaction between bank size and deposit growth (SIZE x DEP): the empirical results presented in Table 5 show that SIZE has a positive and significant (at the 1% level) impact on Z-score. Conversely, DEP has some negative impact on bank stability. Surprisingly, the interaction between these two variables (large size with high deposit growth) leads to deterioration of bank stability (statistically significant at the 1% level). This result may confirm the fact that large banks that tend to attract deposits in order to channel them into risky loans (or other risky businesses), relying on their advanced risk management techniques and diversification, will suffer deterioration in their Z-score.

The interaction between net interest margin and bank liquidity (NIM x LIQ): the previous estimations show that NIM increases bank fragility significantly, whereas LIQ supports bank stability. Overall, the common effect of these two variables results in increasing bank fragility. A possible interpretation for this result is that banks that aim to boost their interest margin through expanding their risky lending, to compensate their holding of high liquidity levels, will face deterioration in their stability. Another possible interpretation is that if a bank adopts a strategy of increasing risky credits to boost returns, while relying on high liquidity as a buffer to overcome any decline in credit quality, this bank will end up facing higher vulnerability.

Table 6. The impact of the interaction among control variables on bank fragility (method: fixed effects)

	1	2	3	4	5	6	7	8	9	10
C	28.33	109.8***	-1.72	157.7***	-502.1***	14.91	144.9***	-201.2***	-2.01	94.2***
	(67.99)	(29.73)	(63.06)	(38.06)	(123.61)	(65.36)	(33.19)	(67.85)	(65.22)	(19.21)
NIM										-15.5**
										(6.06)
SIZE					40.1***					
					(8.65)					
DEP	-0.37			-0.29			-0.30		-041*	
	(0.24)			(0.24)			(0.24)		(0.24)	
LIQ	1.32		1.60*			1.60*			1.56†	
	(0.98)		(0.88)			(0.97)			(0.96)	
CI		-0.69**	-0.61*	-0.81**		-0.67*	-0.78**		-0.62*	
		(0.35)	(0.33)	(0.35)		(0.35)	(0.35)		(0.35)	
BIS	0.06	0.03		0.10	0.37	-0.03	0.13	-0.11	0.06	
	(0.40)	(0.40)		(0.40)	(0.38)	(0.40)	(0.40)	(0.38)	(0.40)	
LLP	0.52	0.54		0.57		0.01	0.71		0.08	
	(1.04)	(1.03)		(1.02)		(1.08)	(1.03)		(1.08)	
GDPG						-0.59		-2.55		
						(2.25)		(2.28)		
INLF		-0.06		0.71	1.84		0.88			0.83
		(1.98)		(2.02)	(1.97)		(2.01)			(1.98)
CONC5								5.6***		
								(1.23)		
SHOCKS			26.38*	24.04						
			(15.78)	(16.12)						

DEP x LLP			-0.03*		-0.02†					
			(0.01)		(0.01)					
SIZE x NIM	-1.10**			-1.5***						
	(0.55)			(0.56)						
SIZE x DEP		-0.03*				-0.03*				
		(0.01)				(0.01)				
NIM x LIQ							-0.21**	-0.20**		
							(0.09)	(0.08)		
SIZE x SHOCKS									2.06*	1.94*
									(1.13)	(1.11)
Adj.- R^2	0.220	0.216	0.228	0.225	0.239	0.218	0.222	0.240	0.222	0.226
Obs.	649	649	652	649	649	649	649	654	649	658
F-stat.	5.256	5.162	5.577	5.200	5.846	5.122	5.215	5.929	5.221	5.703
Prob(F-stat.)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-W stat.	2.01	2.02	2.02	2.02	2.02	2.02	2.02	2.01	2.03	2.01
Hausman test										
χ^2 stat.	64.546	67.654	72.124	70.728	83.544	71.232	67.888	77.691	70.937	70.116
Prob(χ^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note. Standard error in parentheses. ***, **, * denotes significant at the1%, 5% level and 10% level respectively. † Significantly different from zero at the 12% level. D-W stat.: Durbin Watson statistic.

Finally, the interaction between bank size and economic shocks (SIZE x SHOCKS): while larger banks record higher stability than smaller ones (the difference was statistically significant at the 1% level), an economic shock tends to lower the stability of large banks (the positive impact declines from 1% to 10%). This may suggest that economic shocks converge bank Z-score and deprive larger banks from taking advantage of their size.

7. Conclusions and Policy Recommendations

This paper studied the development of bank fragility in Lebanon over the period 1990-2013 using the Z-score indicator. We found a statistically significant increase in Z-score over the studied period. Even after splitting our data set by bank size, we found the same results. This shows that over the past twenty five years, considerable efforts have been undertaken by banks and supervisory authorities to boost banks' stability.

Secondly, we analysed the impact of several bank-specific and external factors on bank Z-scores to detect the determinants of bank fragility. Regarding bank-specific factors, we found that larger banks, and banks holding high liquidity, have higher stability measures. Conversely, higher net interest margin (which may represent an indication for bank pricing power), a high growth rate of deposits, and cost inefficiency, increase bank insolvency risk. As for external factors, the empirical results show that both market concentration and political shocks have a positive impact on bank Z-score.

Thirdly, we tested the impact of the interaction among control variables on Z-score. Interestingly, the empirical results show that the common impact of several explanatory variables has a different impact from that of the variables separately. This stresses the importance of factor interactions on bank fragility and shows that it is not enough to consider how each internal or external factor shapes fragility/stability separately, but it is necessary to detect how these factors coordinate to determine bank Z-score.

Consequently, these findings are important for policy making and suggest that banking prudential regulation should guide banks to build their risk mitigation strategies taking into consideration the interaction among factors.

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Notes

Note 1. Setiyono and Tarazi (2014) used the *tier 1 capital* ratio, whereas we use the *total capital* ratio, as this is the available variable.

Note 2. Lebanese banks have been characterised by their wide regional and international presence, and currently, eighteen Lebanese banks control a wide regional and international branch network. The regional network of Lebanese banks is mainly concentrated in Syria, Egypt, Iraq, Algeria, Sudan, Jordan, Saudi Arabia, Qatar, and the United Arab Emirates.

Note 3. This variable captures a value of 1 during the following years: 1993, 1996, 2005, 2006, 2011, 2012, and 2013.

Note 4. As explained before, $\sigma ROA_{i,t}$ is based on a 3-year period, therefore, the first available Z-score is for the year 1992.

Note 5. Whereas Yeyati and Micco (2007) find that concentration does not have a significant impact on bank risk.

Note 6. We do not report the other pairs that do not have a statistically significant influence on Z-Score, as this does not allow drawing a conclusion.

Appendix A

Calculation of Control Variables

Variable	Calculation
Z-score	$(ROA_{i,t} + E/A_{i,t})/\sigma ROA_{i,t}$
ROA	Net income divided by average assets
E/A	Equity-to-asset ratio
$\sigma ROA_{i,t}$	Three-year standard deviation of ROA
NIM	(interest received – interest paid)/average assets
SIZE	Natural log of assets
DEP	Annual growth rate of bank deposits
LIQ	Liquid asset-to-total assets ratio
CI	Total cost-to-total income ratio
BIS	Basel capital adequacy ratio
LLP	Loan loss provisions-to-total loans ratio
GDPG	Annual real gross domestic product growth rate
INFL	Annual inflation rate
CONC5	Assets of largest 5 banks divided by total banking sector assets
SHOCKS	Dummy variable representing economic and political shocks