Earthquake Losses in the Middle East: Potential Strategies to Improve Insurance Affordability

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Abstract: In the last two decades, less than one-third of the losses caused by natural disasters were insured. High-income countries cover on average 30% of their losses, while low-income countries insured only 1% of their losses. Notably, in most parts of the Middle East, insurance and other disaster risk financing instruments are rarely used. We developed an earthquake loss model covering the residential building stock of 12 countries in the Middle East. Then, we explored different strategies to diversify the risk, and potentially decrease the cost of insurance policies. We demonstrate that aggregating earthquake risk from several countries in the same pool can decrease considerably the cost of insurance in the region, consequently improving affordability.

Keywords: Earthquake losses, seismic hazard, exposure, Middle East, insurance.

1. Introduction

Economic losses due to disasters can represent a significant financial burden to governments due to the statuary obligation to cover response, recovery, and reconstruction costs. Some developed countries can rely on public revenues to fund disasters, which are based on a deep and wide taxation system. On the contrary, developing countries often face ongoing economic pressures limiting their ability to depend on public resources solely. Efficient disaster risk financing strategies use a combination of public and private resources. The high cost of insurance is one of many challenges facing states to obtain sovereign insurance or other risk transfer mechanisms (Cummins and Mahul 2008).

Insurance underwriters need both the expected loss and loss distribution to price premiums. The expected loss for a portfolio is simply the sum of the expected losses for the individual locations. However, the uncertainty of the aggregated loss is not equal to the sum of the individual uncertainties. A positive correlation for a group of random losses can yield extreme values, which affects the distribution of the aggregated losses significantly. Generally, a fair premium reflects the expected loss. However, due to the large uncertainty associated with disaster losses, insurers need to hold a large amount of capital to protect against extreme events. This generates capital costs, and therefore as compensation, insurers load the expected loss by an additional amount proportional to the *riskiness* of the insured portfolio. The additional amount is called the risk premium, and it ensures the survival and profitability of insurers. Risk premium can, however, surpass the expected loss considerably (Kousky and Cooke 2012; Goda *et al.*, 2015b; Lane and Olivier 2008; Cummins and Mahul 2008), leading to unaffordable premiums. Through diversification, insurers can select uncorrelated portfolios, which can reduce the uncertainty and consequently lower their premiums. In this study, the focus is dedicated to portfolio loss volatility and how different diversification options can reduce this variability, which will ultimately reduce premiums, and consequently improve insurance affordability. We investigated four portfolios with different geographical extents, as well as distinct modeling conditions. The factors examined included portfolio size, geographical extent and set of building classes.

3. Catastrophe Premium Pricing

In theory, insurers charge premiums proportional to the level of risk. For instance, the closer the property to a river, the higher the premium. Risk-based premiums account for the three components of risk (i.e., exposure, vulnerability and hazard). A recent review on flood insurance programs in 25 countries illustrated that in most cases, premiums are partially risk-based (i.e., rates are differentiated only based on the hazard intensity), and in some cases, premiums are flat (Atreya et al. 2015). We considered here a risk-based approach to price insurance premiums suggested in a large number of studies (e.g., Kreps 1990; Cummins and Mahul 2008; Dong 2002; Goda *et al.,* 2015):

$$P = p_{pure} + p_{risk} + e \quad (1)$$

Where P denotes the total premium, p_{pure} (pure premium) is the portfolio expected loss E(L), p_{risk} (risk premium) is a proportion of the standard deviation of the expected loss ($\alpha * \sigma_{AL}$), and e refers to the expenses coming from managing, marketing insurance policies, and it also includes a margin for profit. The risk premium is added to protect against the uncertain losses and α is known as the risk load factor, and it is assigned given the insurers' available capital, reinsurance coverage fees, market regulatory conditions (e.g., solvency limits) and attitude towards risk. From equation (1), the total premium is proportional to the loss standard deviation. Goda *et al.,* (2015) argues that the risk premium p_{risk} is not negligible and is relatively large compared to the pure premium.

The variability in the loss estimates simulated from a model depends on several factors. The uncertainty is usually separated into two components: aleatory and epistemic. The former represents the randomness of events (e.g., the chance of observing the 6-face after rolling a dice), this type of uncertainty is treated by exploiting a suitable modeling approach to avoid bias, and this component cannot be diversified. The latter is related to knowledge (e.g., uncertainty in the geographical location of buildings), and this type can be treated by acquiring additional data. For insurance applications, both uncertainties are significant and they contribute directly to the *riskiness* of their portfolios. The factors affecting portfolio loss volatility considered in this study are:

- Portfolio geographical extent and size: when the distance increases between two assets, the chance that both are affected by the same event reduces. We considered in our experiment four portfolios with various geographic extents (local, national, sub-regional and regional).
- Diversity of vulnerability: if a building portfolio is distributed equally across 5 building types, the variability in the loss ratio (LR) is lower than the variability of the LR of a portfolio consisting of one building class. Portfolios consisting of unique buildings are more sensitive to correlation, which leads either to low or high losses, compared to mixed portfolios. We investigated this aspect by considering only one building class in one case, and full diversity (30 building types) in another case.

To investigate how model diversity can influence portfolio loss estimates, we considered four portfolios with different sizes as described below:

- **Portfolio 1**: at the sub-national level (15 thousand buildings – the smallest), located in Beirut (Lebanon), with an estimated surface area of 84 km^2.

- **Portfolio 2**: at the national level (0.4 million buildings): located in Lebanon with an estimated surface area of 10.4 thousand km^2.
- **Portfolio 3**: at the sub-regional level (1.1 million buildings), composed of three countries (Lebanon, Palestine, and Jordan) with a total surface area of 285 thousand km^2.
- **Portfolio 4**: at the regional level (14.8 million buildings - the largest), composed of 12 countries covered (Jordan, Lebanon, Syria, Palestine, Kuwait, Iraq, Saudi Arabia, Yemen, Oman, Qatar, Bahrain and United Arab Emirates), with a total surface area of 3.82M km^2.

We used the probabilistic seismic risk model for the region proposed by Dabbeek et al. (2020) to estimate economic losses for each portfolio, considering different aggregation levels for the building classes. The average annual losses for the 12 countries are presented in Figure 1.

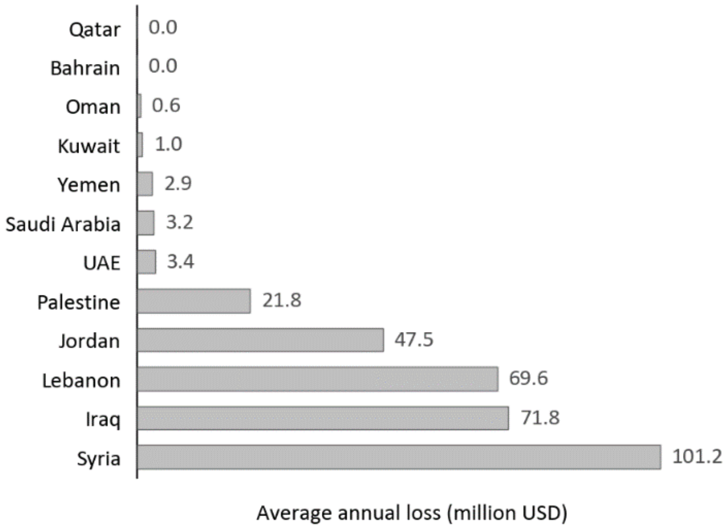

Fig. 1 – Average annual losses for 12 countries in the Middle East due to seismic hazard.

3.1. Impact of the portfolio size

The results in Table 1 illustrate that the variability of losses decreases for larger portfolios. The coefficient of variation decreased by 73% (i.e., from 2.18 to 0.95). Such reduction in the variability is attributed to the geographical distribution of the building stock. Suppose Portfolio 4 is concentrated in a small region, then each event would have affected the entire portfolio simultaneously, leading to extreme losses. As the distance between buildings increases, the loss correlation decreases. It is worth noting that the model considered here assumes full independence between consecutive events, meaning that the occurrence of one event does not affect the others (i.e., time-independent hazard).

Table 1. Portfolio size effect on loss estimates, absolute values are in USD.

Portfolio	AAL (million)	σ_{AL} (million)	CoV	σ_{AL}/RPL (%)
1	7.13	15.5	2.18	0.314
2	72.04	90.9	1.26	0.143
3	121.3	116.6	0.95	0.081
4	302.0	178.0	0.59	0.014

3.2 Diversity in the building classes

Another factor that influences the variability of loss is the number and distribution of building classes. In particular, the diversity of construction is noticeably larger in urban areas than in rural ones (e.g., Dabbeek and Silva 2020). The assumption here is that portfolios with different building classes are less sensitive to correlation than portfolios with a single building class. To explore this aspect, we estimated economic losses for Portfolio 2 using two cases. First, considering all the building classes, and then, considering only one building class at a time. In the latter case, buildings were grouped in four main categories: RC low-rise with low-ductility, RC mid-rise low-ductility, RC mid-rise medium-ductility and unreinforced masonry with no ductility.

The results in Table 2 illustrate that the *CoV* is always larger when considering a single building class, with the exception of RC low-rise low ductility. This building class is particularly evenly distributed across the region (i.e., it is the most common building classes in the portfolio), and thus there is already a significant level of diversification (i.e., losses that occur in a particular area will not be correlated with losses that occur in another distant area). On the other side of the spectrum, we have RC mid-rise with moderate ductility. This building class presents the highest discrepancy in the *CoV*. This case was further explored, and it is was found that mid-rise with moderate ductility buildings are concentrated mostly in two adjacent regions (i.e., Beirut and North mount Lebanon - it only represents 2% of the building stock). This means that there is a high likelihood that any destructive event will affect a large portion of the entire portfolio of this building class. This demonstrates that although the building stock at the national scale seems to be distributed and thus more diversified, there is still a possibility that some building types prevail in one specific region.

Table 2 - Diversity of building types on loss estimates

Cases	AAL (million)	σ_{AL} (million)	CoV
All buildings	74.9	86.75	1.15
Low-rise, low ductility RC	14.62	16.22	1.1
Mid-rise, low ductility RC	32.59	39.74	1.21
Mid-rise, moderate ductility RC	8.1	15.44	1.91
Low-rise unreinforced masonry	19.6	23.6	1.2

4. Diversification Effects on Premiums

The main goal of this study was to explore the benefits of risk pooling in the Middle East. Equation (1) was utilized to estimate a per-country premium before and after diversification. For the second component of the Equation (i.e., risk load factor α), we assumed a constant value (i.e., 20%). This value reflects the appetite for risk; insurers need to keep more capital in hand than the expected loss to protect against large losses. This factor is subjective and depends on many factors, for example, insurance regulators such as governments usually define the acceptable insolvency probability which should not be exceeded. To satisfy this constraint, insurance companies are required to either increase their capital by increasing the risk load or reducing the amount of risk they hold. Risk perception also plays an important role in defining this factor. For example, a survey of underwriters showed that premiums are priced differently according to the ambiguity of risk (Kunreuther et al. 1995). The load value is not trivial, a review of 250 catastrophe bonds showed that the price of catastrophe risk is a function of the peril type, expected loss, risk profile (*riskiness*), and the market cycles. The catastrophe risk price was found 2.69 times the expected loss (Lane and Olivier 2008). We decided to use a minimal value for α based on the literature (Dong 2002). The expense component in Equation (1) is not considered here since this type of information is not available, though statistical analysis of non-life insurance illustrates that the expense ratio is similar in most countries (i.e., 20-25% - Cummins and Mahul 2008).

Table 4.7 depicts the premiums required by each country in two cases, one without diversification (i.e., individual country), and the other with diversification (all states in one pool) represented earlier by Portfolio 4. At the regional level, the reduction in the total premium reached 10%. At the country level, the decrease in premiums varied between 5% to 60%. This variety is obviously related with the range of coefficients of variation depending on the modeling options. For example, Syria has the least volatile losses (i.e., CoV equals 0.87), and thus the premiums dropped only 4.7%. This suggests that the portfolio at the national level is already geographically diversified. It is worth mentioning that the large reductions (i.e., above 15%) are due to significant variations caused by small losses. To illustrate the effect of the load factor (α) on premiums, we assumed a 50% load, which led to a 30% reduction in the total premiums.

Table **Error! No text of specified style in document.**.1. Earthquake premiums before and after diversification.

Country	Individual risk				Pool	
	AAL (million)	σ_{AL} (million)	CoV	Premium (million)	Premium (million)	Difference %
Lebanon	66.80	89.3	1.34	84.67	74.78	11.68
Syria	96.37	84.2	0.87	113.22	107.88	4.71
Palestine	19.29	27.0	1.40	24.69	21.59	12.53
Jordan	49.45	65.9	1.33	62.63	55.36	11.61
Iraq	44.50	53.6	1.20	55.22	49.82	9.79
Kuwait	0.00	0.0	8.99	0.01	0.00	59.99
Oman	0.24	1.1	4.53	0.45	0.27	41.29
UAE	0.05	0.3	6.22	0.10	0.05	50.13
Saudi Arabia	2.81	9.5	3.39	4.72	3.15	33.29
Yemen	1.49	2.5	1.70	1.99	1.66	16.45
Total	-	-	-	347.7	314.5	10

5. Conclusions

This study investigated the effect of diversification on portfolio loss analysis. We explored the sensitivity of the portfolio aggregated loss (mean and dispersion) to portfolio size and building diversity. The results demonstrated that portfolio size has the strongest influence on the volatility of losses. Furthermore, the results illustrated that small homogenous portfolios (with similar structures or soil conditions) are the most sensitive to correlation, and thus, their losses are more volatile. This sensitivity diminishes with the increase of the separation between assets, and with larger portfolios the uncertainty of the aggregated loss decreased despite the degree of diversity in the model components.

The applicability of the proposed catastrophe insurance pool has several limitations. From the organizational side, the pool requires close collaboration among countries. This can be facilitated starting from existing regional organizations that offer necessary frameworks for cooperation. From the supply side, the insurance pool requires a robust local insurance market to access global markets (i.e., reinsurance). This could be a challenging condition in low-income countries (e.g., Yemen, Syria) where insurance markets are immature or disrupted. From the demand side, the need for insurance in some countries (e.g., United Arab Emirates, Oman and Kuwait) seems very low, as these countries are expected to have large resources and little exposure to floods and earthquakes. To make the pool beneficial for them, additional perils that affect this region can be added such as cyclones which affect Yemen and Oman, or sand storms and heat waves that disrupt business in the southern part of the region.

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