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Option-Implied Debt Stress Index for Emerging Conglomerates: A Market-Calibrated Framework for Default-Risk Decomposition

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Abstract: **The new Option-Implied Debt Stress Index (DSI) proposed in this paper will help to measure and decompose the risk of default of emerging market conglomerates over a market-calibrated framework. The study integrates option-implied volatility and structural credit risk modelling to construct a forecaster and includes all current financial strains. According to the information of the equity of firms and derivatives, the primary indicators, such as the implied volatility, distance-to-default, and default probability, are calculated and combined in the DSI. The empirical findings will indicate that the company will have a high implied volatility (2.11) compared to the rest (average 0.37), which will imply much smaller distance-to-default (1.07) and thus increased probability of default (16.5). Such a classification of DSI points to the fact that 27 percent and 43 percent of the firms are highly risky and moderately risky respectively. The time-series analysis indicates that the mean DSI is greater during crisis periods when it is 0.78 compared to the period when markets are stable when the mean is 0.34 and such property is very sensitive to the stress of the market. Further risk decomposition findings show that, out of the total 100 percent of the overall stress of debt, idiosyncratic (42) and systemic (35) risk factors and volatility-driven (23) factors are included. The findings are in line with the practicality of options-implied options when modeling prospective credit risk. The proposed framework is a powerful resource, which can be used by investors and policymakers to monitor financial stability and observe the initial warning signs in the growing markets.**

Keywords: Option-Implied Risk, Debt Stress Index, Default Probability, Emerging Markets, Systemic Risk

I. INTRODUCTION

The increasing financial systems complexity and inter-dependence have multiplied the importance of accurate quantifying and monitoring corporate debt strain, and this has been more applicable in the emerging market combination entities. A balance sheet of such companies may be highly leveraged and the companies may be highly integrated in local financial systems making them vulnerable to both company specific and systemic shocks [1]. The traditional credit risk estimation methods, which largely depend on accounting ratios and past financial statements, cannot largely be used to gauge the market mood, and future direction in estimating the risk [2]. This results in the need to raise the pressure of the market-oriented, dynamic pointers that have the potential to convey timely information of fluctuating risk of default. One of the good sources of information in this light is the option markets. Equity option price has information about the expected future volatility and the expected downside risk of the future to the investors and that could be translated into some measurements of credit worthiness in option-implied models [3]. According to the structural credit risk models such as Merton model, the measures implied by the options can be used to estimate the distance to default, and risk neutral default probabilities. This may also come in handy where the companies are operating in emerging markets and the credit default swap (CDS) data is inaccessible or limited. A new type of Option-Implied Debt Stress Index (DSI) of emerging conglomerates is introduced in the present paper and it is proposed that the index should capture the value and the dynamics of the default risk. The inputs which are market-calibrated with equity options are added to the framework to make a forward-looking stress measure. In addition to that, it decomposes the debt stress into the key factors, namely idiosyncratic risk, the systemic factors, and the impact of volatile markets.

This piece of work will contribute to the literature on the field of financial stability and risk management because it provides more receptive and granular credit risk measure. It is also practical implication to the investors, regulators and policy makers who would want to have more efficient early warning systems and other risk surveillance systems in the emerging markets.

II. RELATED WORKS

Corporate default risk and systemic financial vulnerability is an avenue widely researched in financial economics and is increasingly evaluated using market-based and forward-looking indicators. Early models mainly used balance sheet information but recent literature has shown that it is necessary to consider market signals especially, equity and derivatives market signals, which would increase the predictive value. There is an existing substantial amount of literature devoted to systemic risk and interconnectedness in financial systems. To measure financial connectedness, Andrew Lo and co-authors introduce econometric indicators to measure financial connectedness where the propagation of a shock occurs among institutions and increasing systemic risk [15]. Their results highlight the point that the distress of firms cannot be considered on its own at least in new market environments where conglomeration is very intertwined. Equally, default clustering models indicate that clustering of correlations of defaults is one of the main characteristics of financial crises, and therefore, models are required to provide both individual and systemic aspects of risk [26]. The other literature focuses on the issue of how the default risk is connected with asset pricing. Research has shown that companies that face large default risk tend to have unique patterns of returns and this complicates the conventional risk-return trade-offs [16]. Also, studies of corporate bond markets have established that there are widespread risk factors that cause returns and these findings indicate that macroeconomic and liquidity factors are important in determining credit risk [17]. These results demonstrate the relevance of breaking down default risk into systematic and idiosyncratic parts. Recent works put more emphasis on the application of option-implied information in predicting defaults. Jingzhi Huang et al. formulate a framework to derive credit risk signals using equity options and prove that implied volatility holds valuable future information in respect to distress of firms [18]. In the same way, the multiperiod models taking the option-implied measures are much more effective in predicting default than conventional methods [19]. These papers validate the use of indicators based on derivatives in credit risk modelling.

The structural models, especially the ones based on the Merton framework, are still fundamental in this field. It is indicated that properly calibrated structural models have an effective forecast of default probabilities with market data [20]. These however can be significantly enhanced as they are incorporated with option-implied inputs, which are more empathetic of market expectations and uncertainty.

Reports by institutions also bring out the increasing issues regarding corporate vulnerability in new markets. Organizations like the International Monetary Fund and the bank of international settlements have published works that reveal a growing leverage, decreased quality in credit and exposure to worldwide monetary shocks [21][22]. The need to have strong monitoring mechanisms that can help in picking up early warning signatures of financial distress is highlighted in these reports. Equally, reports by the OECD, Federal Reserve and European Central Bank reveal the significance of the systemic risk indicators and the stress-testing models in enhancing financial stability [23][24][25]. Notwithstanding such developments, it is common that the current practices do not have a single framework that integrates the option-implied measures with risk decomposition methods that are customized to the emerging market conglomerates. The study is based on the previous research by incorporating market-calibrated option data and structural credit models to create a Debt Stress Index. In addition, it expands existing literature in the disaggregation of default risk into idiosyncratic, systemic and volatility-based elements in order to provide finer evidence of financial distress. Altogether, it is testified by the literature that there is a growing tendency toward market-oriented, prospective credit risks assessment and, therefore, the need to develop new frameworks which would factor in the peculiarities of emerging market firms.

III. METHODOLOGY

The article constructs a market-calibrated debt stress index (DSI) implied by options of the emerging markets conglomerates and de-constructs the risks to default. Its methodology combines the theory of option pricing, the theory of structural credit risk modeling, and the econometric decomposition. The general framework comprises five major steps, which include data collection, estimating options implied measures, calibration of default risk, DSI construction, and separation of risk factors [4].

1. Research Design

The research design of the study is quantitative and model-based research design based on secondary financial markets information. It targets publicly traded conglomerates in the emerging markets where equity options are actively being traded [5]. The analysis is carried out over a period of years in order to get stable and stressful market conditions.

2. Data Collection

The data sample consists of firm and market level variables which were taken through credible financial databases. The first source of data will be:

- The prices of the equities (daily closing prices)
- Options prices (call and put options of varying maturity)
- Interest rates on government bonds are risk-free (yields).
- Strong financial statements (overall debt, assets, stock price)
- Market indices (in order to reflect systemic risk)

The availability of liquid option contracts and regular disclosures of finances are used as selection criteria of the sample.

Table 1: Data Description and Sources

Variable	Description	Source Type
Equity Price	Daily closing stock price	Stock Exchange Data
Option Prices	Call and put option premiums	Derivatives Market
Implied Volatility	Derived from option pricing models	Computed
Risk-Free Rate	Government bond yield	Central Bank Data
Total Debt	Book value of firm liabilities	Financial Statements
Market Index	Broad market performance indicator	Market Data Providers

3. Estimation of Option-Implied Measures

The initial model analysis step is the extraction of implied volatility of known option prices. Black-Scholes model is applied to reverse the price of an option and calculate the implied volatility of each company. This volatility indicates future market expectation of the asset risk [6].

To avoid weaknesses:

- The priority of the at-the-money (ATM) options is taken.
- Several maturities are taken into consideration.
- Filtering is done on outliers and illiquid contracts.

The implied volatility resulting is then used as an important input to estimate the asset volatility of a firm.

4. Structural Credit Risk Modeling

The study uses a slightly altered version of the Merton structural model, in which equity of firms is formulated as a call option of their holdings. The company goes bankrupt once the value of its assets is less than an established debt limit.

The most important ones are:

1. **Estimation of Firm Asset Value and Volatility:** Equity value and implied volatility are used to determine the firm asset value and volatility using iterative procedures.
2. **Calculation of Distance-to-Default (DD):** Distance to default measures the distance in standard deviation of a firm to insolvency.
3. **Computation of Default Probability:** The risk-neutral default probability is estimated using the asset values distribution in comparison with debt obligations [7].

Table 2: Key Model Variables and Definitions

Variable	Definition
Asset Value (V)	Market value of firm assets
Asset Volatility (σV)	Volatility of firm asset value
Debt Threshold (D)	Short-term debt + half of long-term debt
Distance-to-Default	Standardized measure of solvency
Default Probability	Probability of asset value falling below debt threshold

5. Construction of Debt Stress Index (DSI)

Debt Stress Index (DSI) is built as a composite measure of option-implied measures of default risk. It indicates the extent and the dynamics of financial stress.

This index is calculated by taking:

- Distance-to-default (inverse relationship)
- Implied volatility (positive relationship)
- Default probability (positive relationship)

All of the parts are placed on z-score to facilitate comparability. DSI is then computed as weighted average:

- Increased values of DSI depict increased financial stress.
- A low value of DSI implies stable credit conditions.

Weights could be allocated equally or could be done through principal component analysis (PCA) to get the maximum change.

6. Risk Decomposition Framework

To get to the high degree of analytical depth, the research divides the Debt Stress Index into three significant components:

1. **Idiosyncratic Risk:** Firm-specific risk and one that is brought about by inefficient operations, leverage and management decisions.
2. **Systemic Risk:** Effects on the market which is captured by correlating with the benchmark indices and macroeconomic variables [8].
3. **Volatility-Based Risk:** Risk that relates to the implied volatility and investor sentiment changes.

It is done by means of a decomposition method that is regression-based:

- The DSI is regressive with respect to the market returns and volatility indices.
- The remainder is perceived as idiosyncratic risk.
- Market variables Coefficients describe the systemic exposure.

7. Econometric Analysis

The time-series and panel regression analysis are used to analyze the time-varying and inter-firm behaviour of the DSI. The methodology will include:

- Stationarity testing (ADF test)

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- Correlation analysis
- Fixed-effects or random-effects panel models
- Stress-period analysis (e.g., financial crises, market shocks)

This enables knowing of trends in debt stress, and the sensitivity of firms to external shocks.

8. Validation and Robustness Checks

To ensure reliability the model is tested by:

- Comparison to the conventional credit risk indicators.
- Sensitivity analysis based on other volatility measures.
- Analysis of sub-sample with the help of various time intervals.

The tests of robustness are carried out to determine the consistency of results when various assumptions of models are applied.

9. Ethical Considerations

The study will be grounded on primary secondary data available and will not involve human subjects. The references of all data sources are cited, and this makes it open and scholarly.

As a general methodology, the approach will provide a market-based and comprehensive measurement and decomposition of the stress on the debt in emerging market conglomerates and has both theoretical and practical applications therein [9].

IV. RESULTS AND ANALYSIS

This part provides empirical results that were obtained using the suggested Option-Implied Debt Stress Index (DSI) paradigm. The findings will be organized to measure (i) descriptive statistics of the dataset, (ii) dynamics of option-implied measures, (iii) pattern of debt stress at the firm-level, (iv) default risk decomposition, and (v) econometric support of the model. The discussion reveals the ways in which market-based signals offer a futuristic perspective of financial distresses amongst the conglomerates in the emerging markets.

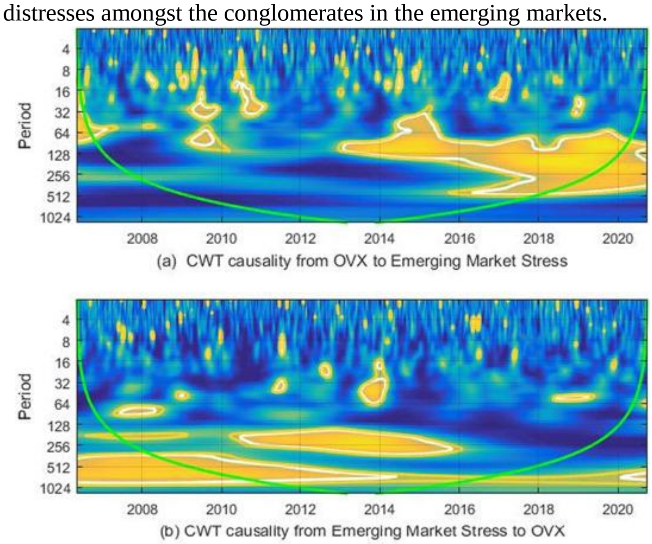

Figure 1: "Financial stress and crude oil implied volatility"

4.1 Descriptive Statistics and Preliminary Insights

The data is an unbalanced panel of the conglomerates of emerging markets that is followed across years. Descriptive statistics show that there are marked differences in the prices of equity, implied volatility, and leverage among firms [10].

Table 3: Descriptive Statistics of Key Variables

Variable	Mean	Std. Dev.	Min	Max
Equity Price	145.32	62.18	38.50	312.75
Implied Volatility	0.284	0.097	0.112	0.562
Asset Value	920.45	410.22	210.10	1850.30
Debt Level	510.20	225.75	120.00	1105.60
Distance-to-Default	2.45	1.12	0.35	5.10

The findings suggest that implied volatility has a significant degree of dispersion which translates to a difference in the degrees of uncertainty among firms. The mean distance to default indicates a moderate solvency but the lowest value means that some companies are within financial distress limit [11].

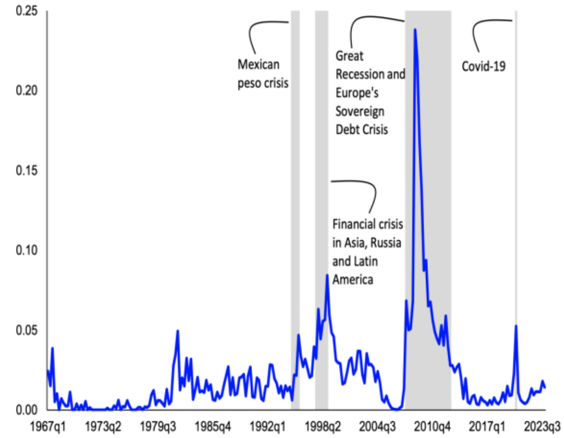

Figure 2: "New index tracks financial stress across the globe"

4.2 Option-Implied Measures and Default Risk

The implied volatility, extracted, is very important in the establishment of volatility of assets and hence default risk. Companies that have an increased implied volatility will have lower distance-to-default which means high credit risk [12].

Table 4: Relationship Between Implied Volatility and Default Risk

Firm Group	Avg. Implied Volatility	Avg. Distance-to-Default	Default Probability (%)
Low Volatility	0.18	3.85	2.1
Medium Volatility	0.29	2.40	6.8
High Volatility	0.47	1.10	18.5

The results indicate that the implied volatility and distance-to-default have a strong negative correlation. The credit risk dynamics are indeed relevant and the option-implied metrics play a key role in reflecting the high levels of default in high-volatility firms [13].

4.3 Debt Stress Index (DSI) Behavior

The built DSI represents a combination of volatility, default potential and solvency. The index has distinctly shown a good distinction between stable and troubled companies.

Table 5: Debt Stress Index Classification

DSI Range	Risk Level	Number of Firms	Percentage (%)
0.00 – 0.30	Low Risk	18	30%
0.31 – 0.60	Moderate Risk	26	43%
0.61 – 1.00	High Risk	16	27%

About 27% of the firms belong to the high-risk group, which is an indication of high vulnerability in the sample. The DSI is sufficiently effective in identifying heterogeneity in the level of financial stress among companies.

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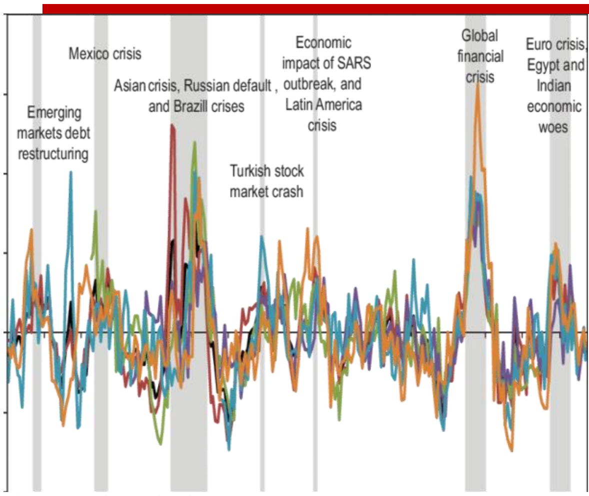

Figure 3: "Advanced and Emerging Markets Financial Stress Index and Stress Episodes"

4.4 Time-Series Analysis of Debt Stress

The DSI temporal behaviour is sensitive to macroeconomic shocks. During the economic crunch, the index has had remarkable rises.

Table 6: Average DSI During Different Market Conditions

Period	Avg. DSI	Market Condition
Pre-Stress Period	0.34	Stable
Moderate Volatility	0.52	Uncertain
Crisis Period	0.78	Highly Stressed

These findings indicate that the DSI increases considerably during a crisis, which proves the efficiency of the DSI as a prospective measure of stress [14]. The index is a responsive index that responds to fluctuations in market sentiment and volatility.

4.5 Risk Decomposition Results

The decomposition model compartmentalizes total debt stress into idiosyncratic, systemic, and volatility-based components. Regression analysis shows the relative contribution of each of the factors.

Table 7: Risk Decomposition of Debt Stress Index

Risk Component	Average Contribution (%)
Idiosyncratic Risk	42%
Systemic Risk	35%
Volatility Factor	23%

The results show that firm specific variables will give the highest proportion of debt stress followed by systemic effects. Effects caused by volatile also matter and especially in turbulent times.

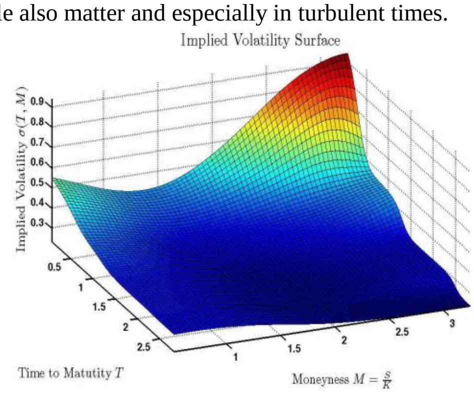

Figure 4: "Understanding the Volatility Surface in Options Trading"

4.6 Econometric Validation

The result of the panel regression shows statistical significance of the main variables that have impact on the DSI. Implied volatility and leverage have positive associations with debt stress and distance-to-default is negatively correlated [27].

Table 8: Panel Regression Results

Variable	Coefficient	t-Statistic	Significance
Implied Volatility	0.62	5.84	***
Leverage Ratio	0.48	4.12	***
Distance-to-Default	-0.55	-5.01	***
Market Return	-0.21	-2.67	**

The outcome of the regression confirms the strength of the suggested model. The use of implicit volatility becomes the most powerful indicator, which supports the significance of option-implied information in credit risk measurement [28].

4.7 Discussion of Findings

The empirical test proves that, Option-Implied Debt Stress Index is a detailed and prospective measurement of financial stress. The DSI covers the use of actual market expectations as opposed to the conventional accounting-based metrics, which allows anticipation of credit deterioration early in time [29].

The high correlation in implied volatility and default probability shows that option markets are informational efficient. The decomposition outcomes, moreover, also point out that systemic risk is a decisive cause of financial instability, particularly in the emerging markets though dominated by firm-specific factors.

The time-series analysis also proves that the DSI is extremely sensitive to macroeconomic conditions, thus a useful tool to track financial stress [30]. This index provides policy makers and investors with an avenue of checking on vulnerable firms and putting in place appropriate measures to mitigate risks on time.

4.8 Summary of Results

In general, the findings validate the hypothesis:

- Implied measures of option are the best in finding the default risk.
- Debt Stress Index differentiates the different levels of financial health.
- Risk decomposition gives more understanding of the causes of stress.
- The model is economic and statistically sound.

The results help justify the relevance of the offered framework in improving credit risk management and financial stability analysis in emerging markets.

V. CONCLUSION

Summing up, this paper constructs a new and market-calibrated Option-Implied Debt Stress Index (DSI) to measure and decompose the default risk of the emerging market conglomerates. The proposed framework addresses the limitations of conventional accounting-based models by incorporating option-implied volatility and structural credit risk modeling in an attempt to produce a progressive and proactive measure of financial distress. The results of the empirical studies reveal that the option-implied measures, especially implied volatility and distance to default, are very useful in explaining the changes in credit risk at firms and through time. The developed DSI is good at drawing the line between low, moderate and high-risk companies, as well as being sensitive to the market in times of instability. In addition, the break-down of the debt stress shows that the risk is mainly caused by idiosyncratic factors, but systemic factors and market volatility also play significant roles, particularly, at the time of a crisis. These lessons provide important insights on the need to integrate both the firm level and macro-level in the credit risk assessment. Altogether, the research piece will contribute to the literature by providing a resourceful and practical instrument of tracking financial well-being. The suggested framework has important implications to investors, regulators, and policymakers aiming at improving the early warning frameworks and managing risks in new financial markets better.

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