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A Systemic Contribution and Vulnerability of Non-financial Firms: A Cross Industry Analysis

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Abstract

This paper quantifies the systemic importance of non-financial firms by assessing their contribution and vulnerability to systemic shocks. We apply two firm-specific measures, namely Delta CoVaR (ΔCoVaR) and Marginal Expected Shortfall (MES), to evaluate the systemic risk of 205 non-financial firms listed on the Pakistan Stock Exchange over the period from 2005-2021. We apply quantile regression methodology to quantify (ΔCoVaR). We confirm that a significant number of firms contribute to both system-wide shocks and are vulnerable to systemic risk of the whole system. We find that firms with a high-risk score in one area are not always high-risk in another. Measures of systemic risk vary significantly across time, between firms and industries. Energy and transport industries are top contributors to systemic risk however, tobacco and pharmaceuticals are among the top industries that are vulnerable to systemic risk of the whole system. We conclude that non-financial firms are systemically important and this risk should be mitigated. This research offers significant insights for policymakers and other relevant stakeholders both domestically and internationally. It aims to help policymakers examine their macro-prudential policy, which now solely takes into account financial firms, to limit the risk that can spread throughout the entire system

Introduction

Systemic risk is the possibility that a shock to one part of the financial system could spread and disrupt the entire system. The collapse of a single institution or component might potentially trigger a cascading impact on other interconnected institutions and markets. Due to interdependences and connections within the financial system, it is challenging to isolate and limit such shocks, which leads to systemic risk.

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The quantification and mitigation of systemic risk came to international attention as a result of bank failures as well as the impairment of the debt and asset-backed securities markets (Dungey et al., 2022). However, (Acharya et al., 2012) contend that the real economic effects of shocks must be part of the systemic risk. They stress while measuring the systemic risk, the connectedness of the financial system along with the real economy must be accommodated to get a broader view of the propagation. Even if firms are financially stable and discretely healthy, prevalent connections within and across industries can transmit adverse shocks into the whole structure, resulting in extensive distraction and becoming a systemic crisis. Furthermore, due to the connections of non-financial firms within the industry and across the industry through trade credit, production and supply chain, financing, and investing needs, these firms are unable to diversify their financial exposure. Dungey and Gajurel (2015) and Dungey et al., 2022) among others, take systemic risk in a broader sense, the risk that domestic adverse shocks, e.g. downfall of a firm or market, will have upshots that have a significant negative effect on the wider economy. Although non-financial firms are not originally part of the financial system, their inextricable linkage to financial institutions is evident via their investing and financing undertakings. These non-financial firms can be systemically risky through their exposure to the financial sector as well as through their own operations and supply chains. So systemic risk cannot be restricted to the financial sector alone and is only applicable if there are consequences for the non-financial firms as well as for the broader economy (Cucinelli & Soana, 2023). Identifying the specific firms and industries with higher or lower systemic risk contribution and vulnerability levels is crucial for a comprehensive understanding of systemic risk in the broader economic landscape. Therefore, the objective of this study is to assess the systemic risk posed by non-financial firms listed on PSX concerning their contribution to systemic risk and vulnerability to system-wide shocks. Additionally, we also analyze firms and industries that contribute more/less to the systemic risk, as well as those that display higher/lower vulnerability to system-wide shocks.

There are plenty of motives to accept that unfavorable shocks experienced by non-financial firms could have potential effects on the financial system and the broader economy, rendering them systemically risky. The interconnections between financial and non-financial firms are evidenced in existing literature (Berger et al., 2020). According to Goldin (2014), when a subsidiary firm in a supply chain defaults, it can negatively impact the productivity of other firms in the network. Korinek et al. (2010) and Duarte and Eisenbach (2021) postulate in what way a shockwave patenting in the financial sector can play a key role in contamination among two unrelated non-financial firms, emphasizing the adverse effect of the original shock and bound them to fire-sale. Similarly, it is indicated in the literature on network models e.g. (Acemoglu et al., 2015), that immense shocks to non-financial firms cause systemic instability. In addition, the empirical evidence that adverse shocks of non-financial firms can be propagated to other segments is described by (Dungey et al., 2022; Dungey et al., 2020;

Jia et al., 2020), with solid confirmation of bi-directional contamination among both financial and non-financial sectors. Non-financial firms are well known to be crucial in the dispersion of shocks, according to research on financial contagion (Cucinelli & Soana, 2023). Non-financial firms create interconnected transaction networks as a result of the benefits of trade credit usage, and default or failure to make timely payments can be propagated throughout the network and become a domino effect.

Despite a substantial body of literature on financial institutions, only a limited number of studies have concentrated on the systemic risk associated with non-financial firms. According to Jia et al. (2020), the systemic importance of sectors other than the financial sector is a fruitful avenue for further inquiry. Optimal risk-taking is higher in financial firms than in non-financial firms due to the anticipated government support during a crisis (Addo et al., 2021). However, following the Global Financial Crisis (GFC), several major industrial enterprises such as Chrysler, Ford, and General Motors obtained emergency loans from the US government due to their systemic importance and the imperative to prevent a broader crisis (Cucinelli & Soana, 2023). Prior literature has largely overlooked the non-financial sector except for a few e.g. (Cucinelli & Soana, 2023; Dungey et al., 2022). It is inevitable to achieve sustainable economic growth without giving due consideration to the non-financial sector along with the financial sector. Furthermore, prior studies that focused on both financial and non-financial sectors largely focused on developed economies with very little or no attention given to developing economies. Various Studies such as (Anginer et al., 2018; Cucinelli & Soana, 2023; Dungey et al., 2022; Dungey et al., 2018; Poledna et al., 2018; Van Cauwenberge et al., 2019; Zhu et al., 2020) have assessed different sets of firms including US, Austrian, Dutch, and Chinese financial and non-financial firms. Their collective findings indicate that non-financial firms pose systemic risk. The financial stability reports of IMF (IMF, 2019, 2022) focus on the indebtedness of firms and warn that corporate indebtedness can have serious consequences for the financial stability of the whole world in general and Asian countries in particular. It is worth arguing that the GFC did not only hit developed countries but also caused disruption in the financial markets of developing economies in the world (Fratzscher, 2012; Neaime, 2012), particularly in developing economies from Asia (Kim & Ryu, 2015; Li & Giles, 2015). Although it has proven challenging to quantify systemic risk, a cross-sectional dimension should be included in all measurements to assess the interconnectedness of systemic risk at a specific point (IMF-FSB-BIS, 2016). This is because systemic risk accumulates over time. Equity prices can be used to calculate the Granger-causality approach of (Billio et al., 2012), the Delta CoVaR (ΔCoVaR) of (Tobias & Brunnermeier, 2016), the SRISK of (Brownlees & Engle, 2017), the marginal expected shortfall (MES) of (Acharya et al., 2017). These systemic risk measurements may be readily created and updated often for any firm listed on a stock exchange and are relatively easy to compute. Although ΔCoVaR and MES methods, compute the systemic risk of an individual firm, they take different standpoints on systemic risk and thus offer complementary insights. ΔCoVaR assumes the disruption of an individual firm and its contribution to the systemic risk of the whole financial system however, MES assumes a financial crisis and assesses the vulnerability of a firm to it. So it is imperative to utilize measures that are reasonably simple to calculate and timely. Additionally, exploring the heterogeneity between these measures is crucial. However, Dungey et al. (2022) also employ ΔCoVaR to measure the systemic contribution of non-financial firms but they take the S&P 500 as a "system", that includes financial and non-financial firms. This can give biased results in the context of the systemic contribution of non-financial firms. We, on the other hand, construct a "system" to measure ΔCoVaR solely based on the growth rate of market-value of non-financial firms included in the sample by following (Brunnermeier et al., 2020). By examining the interactions and dependencies among non-financial firms, this methodology intends to provide a better understanding of systemic contributions that might be overlooked when relying on broader market indicators. A detailed measurement is discussed in the methodology section.

By addressing this gap, this paper contributes to the existing body of knowledge in the following distinct ways: Firstly, this study advances the theoretical frontiers of systemic risk analysis by incorporating Pakistani non-financial firms into the discourse. While the financial sector has traditionally been associated with systemic risk, our research expands on this idea by showing that non-financial firms in developing countries can create and spread systemic risk. Furthermore, it is reported in the systemic risk survey of the State Bank of Pakistan (SBP, 2021) that corporate growth has declined and SBP is keenly observing distressed firms to keep the whole system stable. The rising development in size and the relative significance of the developing markets in Asia may lead to a heightened probability of interconnectedness and contagion. This, in turn, may result in a greater degree of risk transmission across borders and an elevated level of systemic risk (Batten et al., 2015; Shen, 2018; Wang, 2014). Secondly, this study employs two widely used systemic risk measures, ΔCoVaR and MES to obtain the two-dimensional results. These two measures are different in their causality. ΔCoVaR provides information on the contribution of individual non-financial firms to systemic risk of the whole system, whereas MES provides information on how vulnerable individual firms is to system-wide shocks. In addition, this study further explicates forward systemic risk by employing state variables to compute ΔCoVaR as used by (Dungey et al., 2022; Pellegrini et al., 2022; Tobias & Brunnermeier, 2016; Zeb & Rashid, 2019). These systemic risk measures unveiled the fact that any single measure cannot postulate the real picture of systemic risk. By combining systemic risk metrics with ideas from network contagion theory, interconnectivity, and amplification mechanisms, we advance the academic dialogue and offer a conceptual framework that captures the intricacies of how disruptions within non-financial firms of a developing economy can ripple throughout economic networks. By enabling policymakers to regulate systemic risk holistically, this contribution improves financial stability and resilience throughout the economy of Pakistan. Keeping in mind the significance of non-financial firms, the goal of this study is the evaluation of the systemic prominence of non-financial firms of Pakistan in terms of their involvement in systemic risk and their susceptibility to it.

Literature review

Theoretical Foundation and Hypothesis Development

A Risk becomes systemic when the steadiness of the entire financial system is endangered. This definition of Adrian and Brunnermeier (2011) addresses contagion but they adopt a narrow perspective on the system and do not go beyond the banking and non-banking financial institutions. However, systemic risk is an old concept and had been documented and discussed long before the GFC. The definition before crisis, (Settlements, 1992) designates systemic risk as the risk that distress at a firm level or any other economic unit, etc. has far-reaching consequences for other firms, economic units, and the entire financial system. This definition contains contagion at its core. A crisis that becomes systemic corresponds to the soundness or liquidity problems that flow through banking, and non-banking institutions and ultimately becomes a contagion and leads to the disruption of a whole system. Consistent with this definition, (Acharya et al., 2012) quote that financial institutions are systemically important if their failure to meet obligations has significant upshots for the wider economy. They stress the connectedness of the system and state that systemic importance only matters if there is an impact on the broader economy. According to Billio et al. (2012), systemic risk involves the whole system, a collection of related institutions having jointly valuable business associations through which liquidity shortages, losses, and defaults can swiftly circulate in financial crisis periods. Non-financial firms can increase systemic risk by accelerating feedback loops. For instance, businesses may restrict their investment during times of financial stress, which would lower economic activity and add to the financial system's stress.

Despite not being a part of the financial system at the outset, non-financial firms are connected to the financial institutions via their financing and investing activities. In line with this, Battiston et al. (2012) realize that the networks of contagion that belong to systemic risk are intensely connected with the real sector. Contagion effects may result from non-financial sector and financial sector interdependence. For instance, a decline in a particular non-financial sector can have an effect on investor confidence, consumer demand, and employment, all of which affect the overall economy. As a result of higher credit risk, these consequences may then spread to the financial sector and have an impact on the portfolios of lenders. As Chiu et al. (2015) argue, financial firms and non-financial firms are interlinked in terms of debt, and every risky event in the real sector can also expose escalation to systemic risk. Furthermore, Acemoglu et al. (2015) also take it from the real economy to the banking sector and show that when shocks in the real economy are more severe or unexpected, they can be more than enough to activate a flow of disasters across the financial sector, resulting in the fragility of the entire financial network. They further posit that larger shocks to firms in the real economy can be adequate to generate a contagion of defaults across the banking sector, resulting in fragility in the entire financial system. In addition, Tong and Wei (2011) supplement the fact that the financial sector, especially the banking sector, can be directly affected by unexpected shocks in the real economy. So the spillover effect that is significant in the financial system can be produced by the non-financial firms as well as by the financial firms (Beck et al., 2005). The theoretical evidence of trade credit linkage is provided by (Battiston et al., 2007; Boissay, 2006; Kiyotaki & Moore, 1997). They conclude that a firm may fall into a liquidity crisis and fail to pay its suppliers if its customers default on their liabilities. This sequence of default transfers shocks toward the supply chain and ultimately intensifies the destruction of a whole system of inter-firm connections. Non-financial firms frequently rely on complex supply chain networks that span international borders. A single corporation's operations can be disrupted, and this can cause production to stop, revenues to drop, and possibly even financial stress for many different businesses. Following such disruptions, lenders, investors, and other stakeholders may be impacted throughout the financial system (Goldin, 2014). Furthermore, Horvath (2000) and Shea (1995) among others, show that supplier-customer linkages, cannot be ignored in the dispersion of shocks and for the co-movement of enactment between closely linked industries through transaction relationships. When an entity experiences distress or fails, it can trigger a chain reaction of failures in interconnected entities. As one entity's problems spill over to others, it amplifies the impact and can lead to a series of failures. Likewise, in the literature on network models, Acemoglu et al. (2015) state that huge shocks in scale or quantity to non-financial firms can source contagion and create instability in the whole system. So a shock in either sector can cause damage to the other sectors. In addition, Dungey et al. (2022) conclude that non-financial firms that interact with one another and with the entire financial system reveal exposure to systemic shock and become contributors to systemic events through shock diffusion. A failure by a major supplier or customer can have a ripple effect and disrupt the entire supply chain.

Systemic Risk and Non-Financial Firms

Given the importance of non-financial firms in systemic risk, there are very few research works in the literature; some of them are as follows:

In a comparison of US financial and non-financial firms Anginer et al. (2018) confirm that non-financial firms are systemically risky, but this systemic risk is less than the financial firms. In the same manner, Dungey et al. (2018), while developing a systemic risk index of US firms, endorse that non-financial firms are as systemically important as other financial firms, but they do not attempt to analyze the characteristics of systemically important non-financial firms. They take into account a network involving both financial and non-financial firms, asserting that a firm attains systemic importance if its shock is connected to numerous other financial and non-financial shocks, and if its links are more robust with other systemically important firms. On the other hand, Poledna et al. (2018) examine the systemically important non-financial firms of Austria and conclude that interbank linkages contribute only 29% of systemic risk, while interconnection of bank-non-financial firms and inter-firm relations contribute 69%. They discover that non-financial firms play a similar role in systemic risk as banks. Likewise, Van Cauwenberge et al. (2019) analyze Dutch firms and realize that non-financial firms are systemically risky. However, Brownlees and Engle (2017) provide evidence that the non-financial firms suffered quite less from increasing capital shortfalls in the presence of a financial crisis than the financial firms did. While using a sample of US non-financial corporations and financial institutions (Dungey et al., 2022) analyze the determinants of systemically risky non-financial corporations and also compare them with the systemically important financial institutions. They also indicate that non-financial firms are indeed systemically risky. Cucinelli and Soana (2023), examine the corporate governance mechanism of US non-financial corporations listed in the S&P 500 and posit that the corporate governance mechanism of non-financial firms has a significant positive effect on systemic risk contribution and systemic risk susceptibility. Apart from this, Zhu et al. (2020) conducted an analysis of firms in China and discovered that both financial and non-financial firms have the capacity to exert substantial spillover effects on the financial system. Some non-financial firms in developing economies have special financing relationships with other firms, and any potential shock in the financial sector can be produced by these non-financial firms.

In the years following the GFC, the identification of the numerous reasons for systemic risk has been a hot topic in practical and scholarly discourse. The value-at-risk (VaR) is a traditional measure of risk, which estimates extreme fatalities at a certain level of confidence. The VaR was presented by Basel-II as a favored estimator of market risk. VaR fails to capture adequate systemic risk as it is unable to evaluate the interconnectivity among firms. However, consensus has been developed on adopting measures with temporal features to capture the evolution of systemic risk. Simultaneously, these measures possess a cross-sectional dimension to estimate interconnectivity at a specific point (IMF-FSB-BIS, 2016). The ΔCoVaR of Tobias and Brunnermeier (2016) and the MES of Acharya et al. (2017) are two examples of measurements that are solely dependent on market data. ΔCoVaR is a systemic extension of VaR that is based on the tail interdependencies of firms with the financial system. So the ΔCoVaR helps to capture the systemic involvement of individual firms and the propagation of firm-specific shocks to the entire system. However, Acharya et al. (2017) proposed the Marginal Expected Shortfall (MES) to fill the gap between theoretical models and the practical needs of the regulators. MES captures the vulnerability of a single firm to the systemic risk of the whole system. It tells us how an individual firm is being affected by the shocks in the entire system. These measures are widely employed in the literature of non-financial firms and systemic risk e.g. (Anginer et al., 2018; Dungey et al., 2022; Van Cauwenberge et al., 2019). Van Cauwenberge et al. (2019), employ ΔCoVaR measure using DCC-GJR-GARCH estimation, revealing that systemic risk contribution is not limited to the financial sector but, is a significant part of the non-financial sector as well. However, (Dungey et al.,

2022) find heterogeneity between these two measures and conclude that firms that are higher in contribution to the systemic risk of the whole system are not the same and are vulnerable to it. Therefore, relying on a single measure in one study does not accurately reflect the impact of the systemic importance of a firm. Based on the above literature we hypothesize that:

Hypothesis 1: Non-financial firms are systemically risky in terms of their contribution to the systemic risk of the whole system.

Hypothesis 2: Non-financial firms are systemically risky in terms of their vulnerability to system-wide shocks.

Methodology

Sample

The population under consideration for this study comprises non-financial firms listed on the Pakistan Stock Exchange. Our sample consists of 205 non-financial listed firms after cleaning the data for the period of 17 years i.e. from 2005 to 2021. This sample comprises a wide range of industries like Automobile, Textile, Electrical, Chemical, Engineering, Food and Leather etc. This period of 17 years covers four crises, e.g. GFC, the Sovereign debt crisis, the Oil price crash, and the COVID-19 crisis. The empirical evidence on the impact of GFC on the economy of Pakistan is provided by (Haq et al., 2014; Javed et al., 2021) among others. They conclude that the economy of Pakistan witnessed low growth, declining exports and foreign reserves, trade deficit, high inflation, and high unemployment. The listed firms of Pakistan contribute 55% of total exports and about 62% of listed firms are engaged in export activities. The listed firms are the largest in the country as compared to private firms and shared 13% of the GDP of Pakistan in 2017 (Lovo & Varela, 2022). Due to the large market share of listed firms in the economy of Pakistan, the failure of one firm can propagate its shocks to other firms, which can be harmful to the whole economy. The sample includes a significant number of non-financial firms in Pakistan that give a true representation of the country's economy. Weekly stock returns, market return, and state variables are obtained from the Thomson Reuters Data Stream, which is used in our Systemic risk measures. The inclusion of this sample is contingent upon the availability of data throughout the entire sample period.

Variables Measurement

This study computes systemic risk with two popular measures: the ΔCoVaR of (Tobias & Brunnermeier, 2016) and the MES of (Acharya et al., 2017). The reason to apply these measures of systemic risk is to get two-dimensional estimates. One captures the contribution to systemic risk and the other captures the vulnerability to systemic risk (Dungey et al., 2022).

Delta Conditional Value-at-Risk

Delta Conditional Value at Risk (ΔCoVaR) is a risk management metric that assesses the contribution of an individual asset to the tail risk of a portfolio. It is a modified version of the Value-at-Risk (VaR) metric, which is widely used to measure portfolio risk. The "Delta" in Delta CoVaR refers to the change, and the "CoVaR" is short for Conditional Value-at-Risk.

This study estimates a firm's ΔCoVaR to evaluate the systemic effect of a firm's disruption on the system by assessing the variation in VaR of the system under the condition of tail events associated with a specific firm *j*. ΔCoVaR serves as a metric for systemic risk, capturing the cross-sectional tail dependency between the entire system and an individual firm. It is a measure that quantifies the impact of the risk of one portfolio on the tail risk of another portfolio. It is an extension of the Conditional Value at Risk (CVaR), a risk metric that quantifies the anticipated loss in the event of extreme occurrences (Tobias & Brunnermeier, 2016). It is a more comprehensive risk measure than VaR because it takes into account the entire distribution of potential losses rather than just the worst-case scenario (Zeb & Rashid, 2019). The tail event for the firm *j* in a given period is defined as the lowest 5% of its returns.

The following steps will be taken to obtain the values of systemic risk.

The System return is measured with the help of eq. 1 and eq. 2 by following (Brunnermeier et al., 2020).

$$R_t^i = \frac{MV_t^i}{MV_{t-1}^i} - 1 \qquad \text{(Eq. 1)}$$

Where R_t^i is the weekly growth rate of market-value equity of firm *i* at time *t*.

$$R_t^{system} = \sum_{i=1}^{N} \frac{MV_{t-1}^i * R_t^i}{\sum_{j=1}^{N} MV_{t-1}^j} \qquad \text{(Eq. 2)}$$

Where R_t^{system} is the growth rate of the market-value equity of all N firms (i = j = 1, 2, 3, 4…... N) in the whole system at time t.

The VaR of firm *j* is:

$$\text{Probability}\left(r_j \leq VaR_j, 5\%\right) = 5\% \qquad \text{(Eq. 3)}$$

ΔCoVaR depends on the estimation of two conditional VaRs. The CoVaR of the financial market while firm *j* falls in a tail event, is estimated as in the following equation:

$$\text{Probability } (r_{fs} \leq CoVaR(system|j)|r_j = VaR_j, 5\%) = 5\% \qquad \text{(Eq. 4)}$$

Here financial market's return is represented by r_{fs} and r_j represents the return of the firm *j*. This estimation is repeated upon the condition of 50% VaR of a firm.

The ΔCoVaR of a firm will be estimated as in the following equation:

$$\Delta CoVaR\left(R_{fs}\middle| j,\ 5\%\right) = CoVaR\left(R_{fs}\middle| j, 5\%\right) - CoVaR\left(R_{fs}\middle| j, 50\%\right) \qquad \text{(Eq. 5)}$$

Equations 3-5 are run in STATA separately for all firms to obtain the measure of systemic risk. ΔCoVaR represents the variance between VaR of the system, when firm *j* is experiencing distress, and when firm *j* is in its median state. It denotes the change in VaR of the system when firm *j* transitions from its median state to experiencing a left-tail event. The VaR of 5% is considered as a firm is at a distress level and VaR of 50% is considered that a firm is at normal condition, so taking the difference between the distress level and normal level is used to measure systemic risk (Brunnermeier et al., 2020). This study seeks to estimate the measure of systemic risk of an individual firm by calculating two conditional Values at Risk (VaR) of each firm. By following (Brunnermeier et al., 2020; Dungey et al., 2022; Hanif et al., 2021; Tobias & Brunnermeier, 2016; Zeb & Rashid, 2019) this study applies a quantile regression technique to estimate this measure. Unlike traditional linear regression, which estimates the mean of the dependent variable, quantile regression focuses on estimating various quantiles of the response variable. The fundamental concept of quantile regression involves estimating the conditional quantiles of the dependent variable based on the independent variables. This approach provides a more comprehensive insight into the variable distribution and proves beneficial when dealing with a skewed or heavy-tailed distribution of the variable. Incorporating state variables serves to capture the temporal dependence of tail risk. By modeling the variation of ΔCoVaR as a function of these state variables, we can effectively depict the evolution of the joint distribution over time. A greater ΔCoVaR value corresponds to an increased systemic contribution from a non-financial firm.

Marginal Expected Shortfall

Marginal Expected Shortfall (MES) is a risk measure that captures the expected loss of a portfolio that results from adding a new asset to the portfolio. In this study, MES is the value by which firm *j* is marginally contributing to the expected shortfall of the market portfolio. This measure shows how much an individual firm is exposed to a potential systemic crisis (Brunnermeier et al., 2020). MES quantifies the expected loss that is associated with adding an asset to a portfolio. It is a useful measure of risk for portfolio construction and optimization because it allows investors to assess the trade-off between the expected return and the incremental risk of adding an asset to a portfolio. MES is the average stock return of firm *j* for the period when the market has been exposed to systemic events (Acharya et al., 2017). This study defines these events as periods during which market returns reach the 5% tail of their return distribution. This study uses the KSE 100 index in this measure as a financial system (market portfolio) from 2005-2021 as it represents the whole system. The KSE 100 index provides the representation of all the market sectors of PSX. The following is the computation of MES:

$$MES_{j,5\%} = \frac{1}{\#\text{Days Market Return in its 5\% tail}} \sum r_j \qquad \text{(Eq. 6)}$$

$MES_{j,5\%}$ is the marginal expected shortfall of firm j at 5% tail. $\sum r_j$ is the total of firm returns falling in the no. of 5% tail days. Eq. 6 measures the MES of weekly stock returns. The higher the value of MES higher is the systemic vulnerability of a non-financial firm. This study takes the annual average of the values obtained in eq. 6.

Data Analysis and Findings

Descriptive Statistics

Tables I and II present summary statistics of ΔCoVaR and MES respectively at different industry levels. In contrast to MES, ΔCoVaR exhibits a greater mean and standard deviation. This suggests that responses in the market to firm-specific shocks are more significant in comparison to reactions to market shocks originating from specific firms. ΔCoVaR is highest for oil and gas marketing, with firms in the oil and gas exploration, automobile assembler, transport, paper and board, and technology and communication sectors also relatively more contributors of systemic risk in the system. Kerste et al. (2015) and Dungey et al. (2022) also reported that the energy sector has a higher systemic risk. MES also exhibits greater variation across industries but the industries are different than the industries having higher ΔCoVaR values. This variation shows that industries that are contributing to the systemic risk are not vulnerable to the whole market shocks. However, this analysis reveals that non-financial firms exhibit significant systemic risk in certain cases. This risk is notable both in their susceptibility to market shock and their contribution to the overall systemic risk of the entire system, particularly when considering the upper percentiles of both distributions.

Table I: ΔCoVaR across industries. A Descriptive Statistics

Industry	**Mean**	**P25**	**Median**	**P75**	**SD**	**Min**	**Max**
Automobile	-0.42	-6.51	-0.04	-0.04	20.04	-216.52	92.59
Cable & Electrical	-0.92	-8.18	0.01	0.01	14.75	-56.43	38.29
Chemical	-0.08	-4.76	0.01	0.01	11.64	-50.56	52.34
Engineering	-1.12	-9.23	-0.09	-0.09	18.65	-93.14	63.82
Glass & Ceramics	-1.46	-7.15	-1.88	-1.88	12.72	-40.17	49.90
Leather & Tann.	-6.21	-12.06	-1.77	-1.77	14.73	-70.85	22.03
Miscellaneous	-2.73	-6.40	-1.11	-1.11	14.72	-91.00	34.85
Paper & Board	0.85	-4.54	0.04	0.04	10.36	-32.38	40.39
Pharmaceuticals	-1.95	-6.08	-0.70	-0.70	8.42	-34.56	23.49
Power Gen. & Dist.	-1.20	-2.91	-0.00	-0.00	10.09	-73.64	26.41
Sugar & Allied Ind.	-3.74	-8.30	-2.34	-2.34	11.29	-53.32	19.28
Tech. & comm.	0.79	-3.94	1.68	1.68	14.76	-41.53	48.25
Tobacco	-3.12	-5.72	-2.43	-2.43	9.49	-34.13	11.61
Transport	1.33	-3.50	1.13	1.13	10.50	-31.75	24.99
Food & Personal	-2.58	-6.77	-0.63	-0.63	10.98	-55.50	45.89
Oil & Gas	4.98	-0.47	3.86	3.86	9.55	-20.30	35.20
Textile	-6.45	-11.34	-1.59	-1.59	22.87	-247.06	77.47
Total	-2.66	-7.15	-0.43	4.11	17.21	-247.06	92.59

Note. This table summarizes ΔCoVaR a systemic risk measure across each industry group. For the ΔCoVaR measure, this table reports the mean, p25, median, p75, standard deviation, and minimum and maximum values of raw data observed for each year from 2005-2021. These summary statistics are based on raw data without winsorization.

Table II: MES across industries. A Descriptive Statistics

Industry	Mean	P25	Median	P75	SD	Min	Max
Automobile	-5.73	-8.89	-5.57	-1.86	5.91	-35.90	19.90
Cable & Electr.	-5.95	-9.20	-6.53	-1.48	5.46	-21.57	6.14
Chemical	-4.05	-7.54	-3.99	-0.48	6.37	-21.84	45.98
Engineering	-4.17	-8.04	-2.78	-0.01	5.85	-22.07	12.60
Glass & Ceramics	-4.54	-7.86	-4.50	-0.43	5.04	-17.78	6.94
Leather & Tann.	-2.73	-5.46	-2.82	-0.09	7.55	-13.21	43.58
Miscellaneous	-2.70	-7.16	-2.51	0.01	7.54	-16.25	49.58
Paper & Board	-4.98	-6.79	-4.82	-2.49	5.07	-18.21	17.31
Pharmaceuticals	-2.07	-4.31	-2.08	0.14	3.96	-13.06	8.55
Power Gen. & Dis	-4.01	-6.39	-3.37	-0.30	4.72	-25.19	15.34
Sugar & Ald. Ind.	-2.26	-4.89	-0.92	0.09	6.82	-26.80	27.50
Tech. & comm.	-5.51	-9.23	-5.99	-2.77	5.48	-15.79	12.90
Tobacco	-1.11	-3.68	-1.10	0.79	2.89	-6.38	5.79
Transport	-5.33	-7.69	-5.47	-3.08	3.96	-12.11	7.64
Food & Personal	-2.42	-4.99	-1.64	0.00	5.04	-25.78	18.99
Oil & Gas	-7.23	-10.08	-7.27	-4.62	3.80	-15.89	1.77
Textile	-2.50	-5.65	-0.49	0.07	7.08	-43.64	42.17
Total	-3.58	-7.19	-2.90	0.00	6.28	-43.64	49.58

Note. This table summarizes MES a systemic risk measure across each industry group. For the MES measure this table reports mean, p25, median, p75, standard deviation, minimum, and maximum values of raw data observed for each year from 2005-2021 before winsorization.

Table III: ΔCoVaR, MES, and Beta of top 10 firms

Rank	Company	ΔCoVaR	Beta	Company	MES	Beta
1	Dewan Farooq Mot.	8.88	1.75	Khalid Siraj Text	3.39	0.52
2	Attock Refinery	8.43	1.43	Ismail Ind	2.80	-0.10
3	NIMIR Resins	7.92	1.27	Quetta Textile	1.54	0.20
4	Sitara Peroxide	7.75	1.42	Sardar Chemical	1.49	-0.07
5	Dost Steels	7.37	1.29	Shifa Intl. Hosp.	1.47	0.47
6	Crescent Steel	7.35	1.08	Ellcot Spinning	0.96	0.28
7	Pakistan Oil Fields	6.49	1.03	Prosperity Weav.	0.81	0.34
8	Pakistan Petroleum	6.07	1.23	Reliance Cotton Sp	0.59	0.32
9	Sui Southern	6.07	1.03	Sanofi	0.46	0.68

10	Oil & Gas Dev.	5.53	1.16	Chakwal Spinning	0.37	0.76

Note. This table reports the top most risky 10 firms based on the average values of ΔCoVaR and MES as well as the mean Beta of each firm measured over a sample period i.e. 2005-2021.

Table III indicates the top 10 firms in terms of their ΔCoVaR and MES as well as the comparison with Beta of individual firms. Firms that are higher in systemic contribution are different than the systemically vulnerable firms. Firms having higher Beta values are also top systemically contributing firms however, firms having lower Beta values are more vulnerable to system-wide shock.

Table IV: ΔCoVaR and MES of all industries from top to bottom

Rank	Industry	ΔCoVaR	MES	Industry	MES	ΔCoVaR
1	Oil & Gas	4.98	-7.23	Tobacco	-1.11	-3.12
2	Transport	1.33	-5.33	Pharmaceuticals	-2.07	-1.95
3	Paper & Board	0.85	-4.98	Sugar & Allied Ind.	-2.26	-3.74
4	Tech. & Comm.	0.79	-5.51	Food & Per. Care	-2.42	-2.58
5	Chemical	-0.08	-4.05	Textile	-2.50	-6.45
6	Automobile	-0.42	-5.73	Miscellaneous	-2.70	-2.73
7	Cable & Electrical	-0.92	-5.95	Leather & Tanneries	-2.73	-6.21
8	Engineering	-1.12	-4.17	Power Gen. & Dist.	-4.01	-1.20
9	Power Gen. & Dist.	-1.20	-4.01	Chemical	-4.05	-0.08
10	Glass & Ceramics	-1.46	-4.54	Engineering	-4.17	-1.12
11	Pharmaceuticals	-1.95	-2.07	Glass & Ceramics	-4.54	-1.46
12	Food & Personal Care	-2.58	-2.42	Paper & Board	-4.98	0.85
13	Miscellaneous	-2.73	-2.70	Transport	-5.33	1.33
14	Tobacco	-3.12	-1.11	Technology & Com.	-5.51	0.79
15	Sugar & Allied Ind.	-3.74	-2.26	Automobile	-5.73	-0.42
16	Leather & Tanneries	-6.21	-2.73	Cable & Electronics	-5.95	-0.92
17	Textile	-6.45	-2.50	Oil & Gas	-7.23	4.98

Note. This table represents all industries in the sample ranked from the most risky to the least risky, utilizing ΔCoVaR and MES measures.

Table IV indicates that oil and gas, transport, paper and board, technology and communication, and chemicals are the most risky whereas, textile, leather and tanneries, sugar and allied industry, and tobacco are the least risky industries in terms of their contribution to systemic risk. However, tobacco, pharmaceuticals, sugar and allied, food and personal care, and textile are the most risky whereas, oil and gas, cable and electrical, automobile and technology and communication are least risky in terms of their vulnerability to system-wide shocks. We find great variation again and find no industry in the top 10 of both measures. Industries that are higher contributor lies at the bottom in their vulnerability scores. The striking absence of a positive correlation between ΔCoVaR and MES demonstrates that the most susceptible firms to a systemic crisis are frequently not the same as the firms that have the greatest contribution in such an occurrence. As a result, it is essential to examine both dimensions of systemic risk because concentrating solely on one dimension would lead to the omission of vital information regarding risk and the formulation of less effective measures to stop its propagation.

Table V. ΔCoVaR of Top Three Companies from each Industry

Rank	Company	Industry	ΔCoVaR	Company	Industry	ΔCoVaR
1	Dewan Farooq M	Automob.	8.88	K Electric	Power Gen.	2.91
2	Honda Atlas Cars	Automob.	3.32	Sitara Energy	Power Gen.	0.92
3	Pak Suzuki Mot	Automob.	2.74	Kot Addu Pow	Power Gen.	0.67
1	Pak Elektron	Cable & Elect.	2.72	Noon Sugar Mil	Sugar & Al.	-1.52
2	Siemens Eng	Cable & Elect.	-0.17	Mehran Sugar	Sugar & Al.	-1.77
3	Waves Corp	Cable & Elect.	-0.81	Shahtaj Sugar	Sugar & Al.	-2.04
1	Nimir Resins	Chemical	7.92	Pak. Tele. Co.	Tech. & com	4.85
2	Sitara Peroxide	Chemical	7.75	Worldcall Tele	Tech. & com	4.17
3	Lucky Core	Chemical	4.26	Telecard	Tech. & com	0.80
1	Dost Steels	Eng.	7.37	Abbott Lab	Pharma	0.49
2	Crescent St	Eng.	7.35	Glaxosmith	Pharma	-0.67
3	Ds Ind.	Eng.	4.55	Wyeth Pak	Pharma	-0.69
1	Ghani Glass	Glass & Ce	1.85	PIA	Transport	2.72
2	Baloch. Gl	Glass & Ce	0.37	Pak Nat Ship	Transport	0.91
3	Tariq Glass Ind	Glass & Ce	-0.03	Pak Int. Cont.	Transport	0.36
1	Pak Leather Craft	Leather & Tan	-2.17	Goodluck Indus	Food & Per.	-0.00

2	Bata Pakistan	Leather & Tan	-3.59	Treet Corp	Food & Per.	-0.84
3	Service Ind	Leather & Tan	-4.90	Shezan Int.	Food & Per.	-0.95
1	Siddiqsons Tin Pl	Misc.	4.45	Attock Refinery	Oil & Gas	8.43
2	Pak Hotel Dev.	Misc.	0.18	Pak Oil Fields	Oil & Gas	6.49
3	Tri-Pack Films	Misc.	-0.77	Pak Petroleum	Oil & Gas	6.07
1	Packages	Paper & Board	5.37	Hira Textile	Textile	4.25
2	Security Paper	Paper & Board	1.60	Amtex	Textile	3.06
3	Merit Packaging	Paper & Board	0.97	Chenab Susp	Textile	2.96
1	Philip Morris	Tobacco	-3.02			
2	Pakistan Tobacco	Tobacco	-3.23			

Note. This table reports the top (most risky) 3 firms from each industry in the sample based on the ΔCoVaR measure. The 17 industry groups are included in the whole sample.

Tables V and Table VI list the top (most risky) 3 firms from each industry based on both measures (ΔCoVaR and MES) employed in this study. This table reveals that both measures have different results, the firm that is at the top in one measure does not stand at the top in another measure except in the Leather and Tanneries industry where Pakistan Leather Craft stood at the top in both measures. Table V indicates that firms from automobile, oil and gas, engineering, technology and communication, and textile sectors are contributing more to systemic risk of the whole system. However, table VI indicates that firms from the textile, food and personal care, chemical, pharmaceuticals, and tobacco industries are more vulnerable to system-wide shocks as compared to firms from other industries in the sample.

Table VI: MES of the top three companies from each Industry

Rank	Company	Industry	MES	Company	Industry	MES
1	Atlas Honda	Automobile	-2.17	Pak Paper	Paper & B	-2.03
2	Dewan Aut Eng.	Automobile	-3.18	Security Paper	Paper & B	-3.75
3	Hinopak Motors	Automobile	-3.55	Merit Packag.	Paper & B	-5.40
1	Imperial	Cable & Elect.	-2.89	Sanofi	Pharma	0.46
2	Siemens Eng.	Cable & Elect.	-3.40	Searle	Pharma	-1.04
3	Waves Home App	Cable & Elect.	-7.09	Glaxosmith	Pharma	-1.44
1	Sardar Chem. Ind.	Chemical	1.49	Altern Energy	Power Gen	-0.66

2	Leiner Pak Gel	Chemical	-0.80	Pakgen Power	Power Gen	-1.94
3	Wah Nobel Chem.	Chemical	-1.52	Sitara Energy	Power Gen	-2.50
1	Metropolitan St.	Engineering	-1.18	Shahtaj Sugar	Sugar	-0.79
2	Pak. Engineering	Engineering	-1.41	Premier Sugar	Sugar	-0.83
3	Dadex Eternet Ltd	Engineering	-1.64	Sindh Ab Sgr	Sugar	-1.21
1	Karam Ceramics	Glass & Cer.	-2.34	Pak Datacom	Tech Com	-2.61
2	Ghani Value Glass	Glass & Cer.	-2.91	Media Times	Tech Com	-3.07
3	Ghani Glass	Glass & Cer.	-3.52	Hum Network	Tech Com	-5.34
1	Pak Leather Craf	Leather & Tann	-0.40	Khalid Siraj	Textile	3.39
2	Leather Up	Leather & Tann	-1.68	Quetta Textile	Textile	1.54
3	Bata Pakistan Ltd	Leather & Tann	-3.97	Ellcot Spin.	Textile	0.96
1	Shifa Intl Hosp	Miscellaneous	1.47	Pak Int. Air	Transport	-3.92
2	Goc Pak	Miscellaneous	-0.47	Pak Int. Cont.	Transport	-5.46
3	Pakistan Hotel Development	Miscellaneous	-0.89	Pak Nat Ship	Transport	-6.61
1	Ismail Ind.	Food	2.80	Sui Southern	Oil & Gas	-5.87
2	Punjab Oil	Food	0.28	Nat. Refinery	Oil & Gas	-6.36
3	Goodluck Ind.	Food	0.12	Pakistan Petro	Oil & Gas	-6.78
1	Pakistan Tobacco	Tobacco	-1.11			
2	Philip Morris	Tobacco	-1.11			

Note. This table reports the top (most risky) 3 firms from each industry in the sample based on the MES measure. In the Tobacco industry, there are only two firms.

Conclusions and Discussion

Due to the crisis, which accelerated the diversion that was already underway in the banking industry and its associated credit derivative markets (He and Krishnamurthy, 2019), abundant research has been focused on the systemic risk of banking and non-banking institutions and ignored the role of non-financial firms. Systemic risk is indeed a risk that spreads throughout the whole system, and non-financial firms are part of this system. This interdependence among financial and non-financial firms and interconnection among firms within industry and across industry make non-financial firms systemically important. Past studies (Dungey et al. 2018; Zhu et al. 2019; Dungey et al. 2022 etc.) focus on the developed countries like the US, Europe and China. They all provided evidence of the systemic importance of non-financial firms. Although during the sample period of this study, all crises initiated from developed countries and then spilled over to developing countries, this study is a valuable insight for the policymakers and other stakeholders within a country and across the country. This study takes the initiative in measuring the non-financial firms' systemic importance in a developing country like Pakistan. This study conceptualizes the addition of non-financial firms from Pakistan into the discussion, which broadens the scope of the existing scholarly work on systemic risk. To take more prudent measures to mitigate the risk that can spread throughout the entire system, this study assists policymakers in reviewing their macroprudential policy, which now solely takes into account financial firms. Furthermore, this discovery has important ramifications for regulators, legislators, and other stakeholders. To achieve sustainable growth for all firms, non-financial firms must be equally examined to prevent the contagion impact of a crisis in one firm or market and lessen the losses resulting from it.

In this study, we conceptualize that non-financial firms have significant importance in the systemic risk of the whole system. It is important to comprehend this component of systemic risk since the academic literature has paid very little attention to how it spreads systemic occurrences. Drawing on data from 205 non-financial firms listed on the Pakistan Stock Exchange from 17 industry groups for a comparatively longer period i.e. 2005-2021. During this period the world's four major systemic crises e.g. GFC, sovereign debt crisis, oil price crash, and COVID-19 have occurred. We measure systemic risk with two widely used proxies ΔCoVaR and MES to obtain two-dimensional results. We find that non-financial firms contribute and become vulnerable to systemic risk of the whole system in Pakistan. These firms have a potential contagion effect and transmit their exposures to their respective industries as well as across the industries. However, consistent with the past studies and objectives of this study, we find heterogeneity between two measures that firms and industries that are highly contributing to the systemic risk are not the ones that are vulnerable to the systemic risk. The scope of this study is confined to data availability, encompassing solely 205 non-financial firms. However, future research endeavors could broaden this scope by incorporating a larger dataset. Furthermore, exploring a comparative analysis between financial and non-financial firms could be a promising avenue for subsequent studies.

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