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How SMEs Performance Drives the Exportation Ecosystem Resilience

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Abstract: **Exportation ecosystems are highly complex and can collapse when subjected to local and global disruptions. Similarly, unsuitable topology structures (network structures) and performance of SME sector can affect the growth of economic resilience. These two factors are necessary for the exportation ecosystem resilience and organizations to withstand and remain operational during economic shocks. This study investigates the conditions that shape the robust structure of exportation ecosystems. The effective exportation topology structure will thus have a capacity of absorbing and withstanding disruptive economic events triggered by the exportation. Each country has a different strategic approach to combat the risks that may arise when subjected to the perturbation. This study raised the question of why are some economies in the G20 nations much better in resilience than others during a crisis. The results show that the robust topology network of exportation and the performance of small and medium sectors enhance the exportation resilience in the G20 ecosystem. This study's results-based implications will help strengthen the system's resilience against local and global disruptions.**

Keywords: **small and medium enterprise, ecosystem resilience, innovation, Lotka-Volterra, Dynamic Mode Decomposition, exportation resilience.**

I. INTRODUCTION

The SMEs performance and exportation topology structure play an important role in the vitalization of small and medium enterprises to absorb the economic risks and thus enhance exportation. Furthermore, results from regression analysis indicated that metropolitan regions with a more robust technological knowledge topological (network) architecture unveiled higher levels of resilience with respect to changes in employment rates. The findings are strong to various random and targeted firms' ecosystem risk mitigation strategies concerning the most frequently combined technological abilities. Moreover, it was found that economic zones with high employment levels in the industrial sector but with a vulnerable technological aptitude base are particularly challenged by this aspect of county economic resilience. Gathii and Keth, (2012) investigated the functioning ecosystems and has been observed that, the system play an important role in giving goods and services needed to sustain human life. Their examination based on the water provision and filtration, biodiversity, nutrient cycling, climate adjustment and thus, recent research on topological architecture in services has exposed the shockingly high local, regional, and global costs of losing these essential goods and services. Other researchers examined the topological architecture in desert ecosystem following the flash flooding in Arizona and found that temporal trajectories of diversified and ecosystem attributes are compared with those to be diagnostic of successional status (Fisher et al., 1982)

Diversified SMEs sectors can condition exportation resilience. Researchers on the study of tourism as one sector that contributes to economic resilience was investigated and found to enhance economic recovery (Cheng & Zhang. 2020). This constructed one index topology of economic resilience, quantified the economic resilience index, and examined whether tourism enhanced economic recovery following the Wenchuan earthquake risk. The empirical results unveiled that the economic resilience index (degree) (ERI) using the methodological approach presented an increasing trend for all the disaster-affected economic areas from 2008 to 2016, unveiling that the economy in all the economic zones continued to recover from the Wenchuan earthquake; however, there is a large spatial variety amongst them. Most economic areas with a tourism-based economic ecosystem model have a lower resilience degree but higher average growth rate than those without.

II. MATERIALS AND METHODS

A. General Theory of Complex Systems

This research study adopts the general theory of the complex systems approach (Janzwood & Piereder, 2020) and thus apply Lotka-Volterra and dynamic mode decomposition to simulate the role of small and medium enterprises performance and exportation topological architecture resilience to strengthening the exportation growth. Lotka Volterra system theory approach highlights systems' nonlinear, networked, adaptive, and emergent behaviour (Bento et al., 2020). Therefore, first, we develop a new non-linear system model based on the Lotka-Volterra model system approach and reduced it from multi to one dimension for making simulation feasible in optimizing the results. The rationale behind model ecosystem reduction is to enhance the efficiency and reliability the results of resilience quantification (Laurence et al., 2019). The stepwise derivation of the model system is analyzed to get the final model equation that will simulate the results optimally.

Let $x_i \in \mathbb{R}$ be the revenue growth rate of small or medium sector at node i at time t with the assumption that it has any business interaction with other SM sector. The small and medium sectors are nodes in the networks, and transactions are corresponding edges, as shown in. The highest potential revenue growth rate of a sector $K_i(K_i > 0)$ with an intrinsic growth rate constant in the non-linear equation $\alpha_i(\alpha_i > 0)$ as per logistic model for this SM sector and get the dynamic equation as follows

$$dx_i/_{dt} = e_i x_i + \alpha_i x_i \left(1 - x_i/_{K_i}\right)\left(x_i/_{C_i} - 1\right) - p_i x_i + \sum_{j=1}^{N} \beta_{ij} x_i x_j \Big/_{d_i + e_i x_i + h_j x_j} \quad (1)$$

And reduced to

$$dx_{eff}/_{dt} = e_{eff} x_{eff} + \alpha x_{eff} \left(1 - x_{eff}/_{K}\right)\left(x_{eff}/_{C} - 1\right) - p_{eff} x_{eff} + \beta x_{eff}^2 \Big/_{\left(d + (q + r)x_{eff}\right)} = 0 \quad (2)$$

Also

Let us denote the input-output transaction matrix for the $k - th$ year with

$T^{t(k)}$; $t(k) = 2012, 2013, , \dots, 2020$; $k = 1, 2, 3, \dots, 11$, (see Fig. 1), whose specific entity $T^{t(k)}(i, j); i = 1, 2, 3, \dots, 25$; $j = 1, 2, 3, \dots, 25$ is the total transaction from $i - th$ SME sector to $j - th$ firm. Each matrix at $k - th$ year vectorized by stacking the columns one underneath of other to form a 625×1 single vector, i.e.,vector of the matrix $T^{t(k)}$, denoted as $\text{vec}(T^{t(k)})$ is $\left[T^{t(k)}(1,1), T^{t(k)}(2,1), \dots, T^{t(k)}(33,1), \dots, T^{t(k)}(1,25), T^{t(k)}(2,33), \dots, T^{t(k)}(25,25)\right]^{\tau}$, the superscript τ denotes the transpose. Subsequently, $\text{vec}(T^{t(k)})$ for a single country of all 21-years united into a single 1089×21 tall and skinny data matrix: $T = \begin{bmatrix} | & | & | & & | \\ T^{2012}(i,j) & T^{2013}(i,j) & T^{2014}(i,j) & \dots\dots\dots\dots & T^{2020}(i,j) \\ | & | & | & & | \end{bmatrix}$.

A. Dynamic mode decomposition methodology of the input-output transaction

The tall and skinny vectorized input-output transaction matrix T arranged into two matrix T_1 and T_2:

$$T_1 = \begin{bmatrix} | & | & | & & | \\ T^{2012}(i,j) & T^{2013}(i,j) & T^{2014}(i,j) & \dots\dots\dots & T^{2019}(i,j) \\ | & | & | & & | \end{bmatrix},$$

$$T_2 = \begin{bmatrix} | & | & | & & | \\ T^{2013}(i,j) & T^{2014}(i,j) & T^{2015}(i,j) & \dots\dots\dots & T^{2020}(i,j) \\ | & | & | & & | \end{bmatrix}.$$

The dynamic mode decomposition technique seeks the dominant eigenvalues and eigenvectors of the best-fit linear operator A that relates the two input-output matrices in time: $T_2 \approx AT_1$. The best fit operator A then establishes a linear dynamical SMEs system that best advances input-output transactions matrix forward in time. If the sampling is uniform in time, this becomes: $T^{t(k+1)} = AT^{t(k)}$. A simple computation reads to $A \approx T_2 T_1^{\dagger}$, where † denotes the Moore-Pen-rose pseudoinverse. It can be estimated by minimizing the Frobenius norm of the difference: $T_2 - AT_1 \equiv T^{error}$.

The operator A is a matrix with a size of 400×400, implying that it has a total of 400 eigenvalues and corresponding eigenvectors. To preserve (discard) the eigenvectors reflecting the macroscopic SMEs transaction (microscopic details from noises and occasional transactions) of T_1, the singular value decomposition (SVD) is adopted (the detailed of SVD refer [19 20]), i.e., $T_1 \approx U_r \Sigma_r V_r^*$, where * denotes the complex conjugate transpose, r refers to the number of the preserved rank of the data matrix and it is less than or equal to $\min(400,10) = 10$. U_r and V_r is the eigen-time points and eigen-transaction, respectively, which span the space of time points of transaction and industry-industry transactions.

The dominant dynamic underlying input-output SMEs transaction can be captured by truncating to a small value of r. Herein, we find the truncation value r by ignoring components with relative variance is less than 0.005 threshold, because the cumulative relative variance of components with the relative variance greater than 0.005 is greater than 0.98 for all input-output transaction. Using the component of the SVD, the operator A approximated as $\tilde{A} = T_1 V_r \Sigma_r^{-1} U_r^*$, but the size of matrix $\tilde{A}$ is still 400×400. A low-dimensional is efficiently performed by projecting using the first r left singular vectors (U_r). The reduced operator defined to be $\bar{A} = U_r T_1 V_r \Sigma_r^{-1} U_r^* U_r = U_r T_1 V_r \Sigma_r^{-1}$, whose eigen-decomposition read, $\bar{A}W = W\Lambda$, where the columns of $W \in \mathbb{C}^{r\times r}$ and the diagonal entries $\mathrm{diag}(\omega_1, \omega_2, \omega_3, \ldots, \omega_r)$ of $\Lambda \in \mathbb{C}^{r\times r}$ are the eigen-vectors and the eigenvalues of $\bar{A}$, respectively. Then, W is used to approximate the eigen-vector (dynamic mode) of A. The approximated dynamic mode corresponding to the ω_k is $\varphi_k = T_1 V_r \Sigma_r^{-1} W_k$, where W_k is the $k-th$ column of W.

The dynamic modes describe how transaction are related (each industry/sector in industries structure). Within a single dynamic mode each element in a column (φ_k) has two important pieces of information; the magnitude of element (absolute value) provide a measure of industry transaction participate in the mode. The angle between the real and the imaginary component of the element provides a measure of the industry transaction phase of oscillation relative to others for that mode's frequency. By using the approximate eigen-decomposition, we reach a coupled transaction-temporal model, $T_{\mathrm{dmd}}^{t(k)} = \Phi\Lambda^{t(k)} b$, where b is a set of weights satisfying $T^{2012} = \Phi b$, generally Φ is not a square matrix so that $b = \phi^{\dagger} T^{1995}$. Note that entries of b are coefficients of the linear combination of T^{2012}in the eigen-modes basis, we call them DMD amplitudes.

III. RESULTS AND DISCUSSIONS

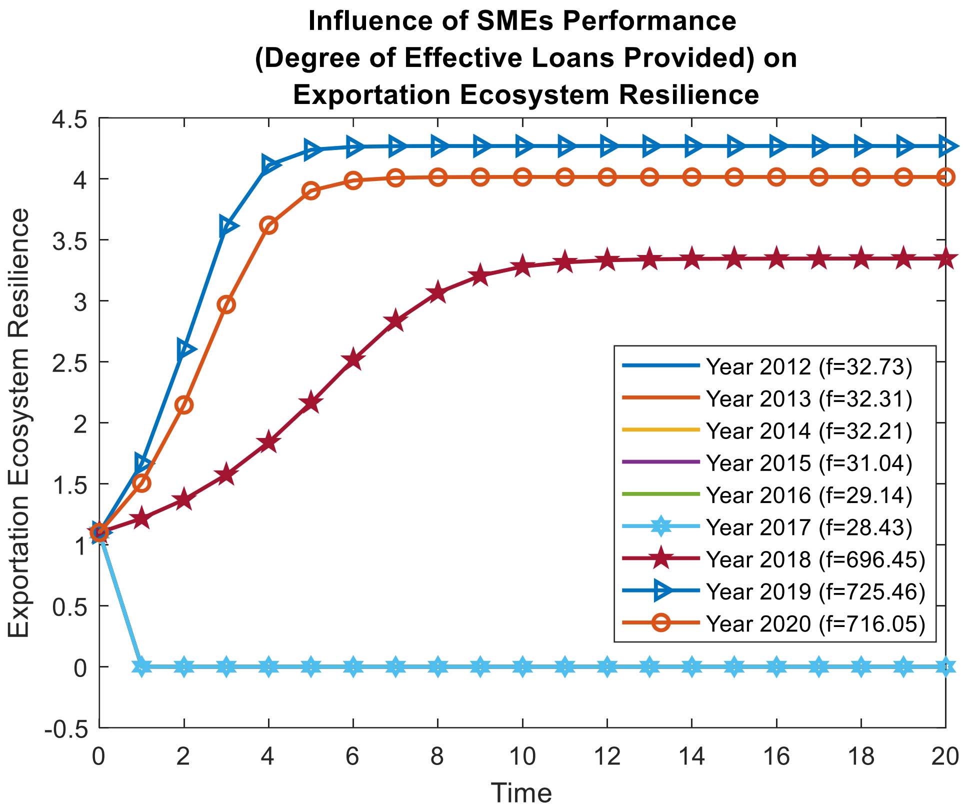

Figure 1: (a)Variation of SMEs Performance in G20 Economic Regions (b) Influence of SMEs Performance on Exportation

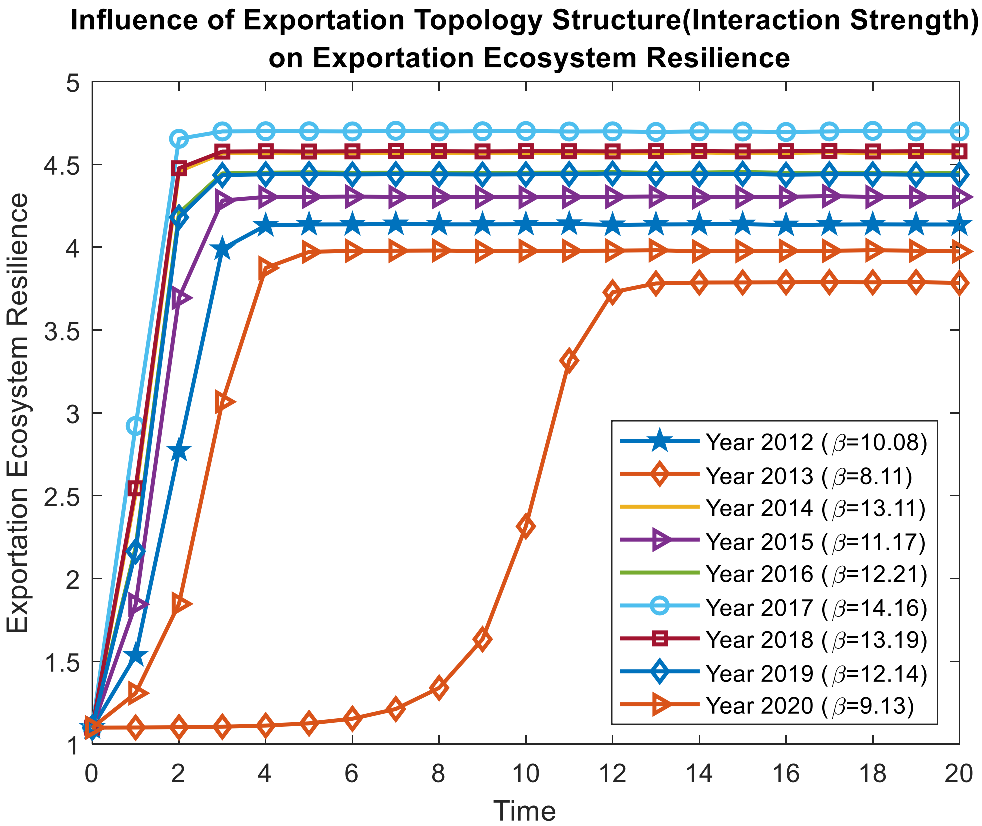

Figure 1: (a) Variation of exportation topological architecture on exportation resilience

IV. DISCUSSION

a The results confirm that the varying network structures of SMEs and exportation ecosystems reveal the different degrees of exportation system growth and collapse. Moreover, the role of interest rates, patent application, innovation index, SMEs performance was investigated. The results from the state function showed that the rise of interest rate pushes the SMEs ecosystem towards collapse, as shown in Figure 16. The figure further indicates that, as interest rates increases, the system moves towards a preventing the growth of SMEs resilience.

From 2012-2013 and 2020, the global network density and heterogeneity dropped while growing from 2017 to 2018, especially in 2017. The network density and average degree caused the interaction strength to vary, leading to changes in the ecosystem structure. As per results, the network structure was weakest during the year 2013 and observed strongest during 2017. The outcomes further unveiled the influence of exportation network structure on resilience. They kept that the more robust network structure makes the system delay the critical transition and the tipping points and thus we say the system is strong resilient. These empirical outcomes indicate that more robust exportation architecture means higher system resilience, hence, withstands the shocks at a larger value of interest rate surge.

Despite the changes in network structure, the rise of research expenditure, patent application and innovation index push the SMEs system towards growth. The role of the innovation parameters are further revealed in the variant location of feasible economic regimes. The results depicted in Figure 1 show that, despite the role of network structure on ecosystems, an increase in these innovation parameters causes the SMEs system to gain resilience. The resilience improvement pushed the system towards a feasible economic regime because the discoveries of new ideas and products will finally promote the sustainable growth of the SMEs ecosystem.

The varying network structure also plays a vital role in the resilience of a country's exportation ecosystem. The results confirm that the increase the topological architecture of the exportation ecosystem promotes the exportation resilience within G20 exporting countries ecosystem. **Error! Reference source not found.** 19 show that the year with highest value of topological architecture was experiencing the highest degree of exportation resilience.

Figure 18 unveils the variation in the effective loans applied in SMEs sectors and represents the performance of the SMEs and was confirmed that as the performance rise the exportation resilience also improves. Generally, the innovation index, research expenditure, patent application and interest rates have been confirmed to affect the growth of SMEs ecosystem resilience while SMEs performance and exportation network structure affect the exportation ecosystem.

V. CONCLUSION

The exportation ecosystems are facing different challenges like weak topological structure of exportation ecosystems. However, few countries like the US China, South Korea, Japan and German manage to overcome the disruptions while the others fail and collapse or grow slowly. Therefore, this study examines the impact of topological structure of the exportation system and the performance of the SMEs on the enhancement of the exportation resilience in the G20. The findings further show how the topological architecture of the exportation ecosystem and the performance of SMEs sector affect the resilience growth of exportation ecosystem and the economy at large. We developed a mathematical model adopted from the Lotka-Volterra model to understand this complex relationship and to find empirical outcomes. The results reveal that business interaction through SMEs strengthens the exportation network and boosts the growth in the exportation of goods and services, eventually influences the other economic sectors, and boosts economic resilience. The improvement of the SMEs performance shows the potential key towards the exportation growth of discovering. The technological transfer and industrial innovation are coupled with inbound SMEs that boost its output, uplift employment opportunities per-capita income, and boost aggregate demand, which, as a result, strengthen the industries and uplift economic resilience and exportation as particular.

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