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The Role of COVID-19 towards the Platform Ecosystem Tipping Points

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Abstract: **This study develops a complex model and investigates the impact of the recent COVID-19 pandemic outbreak on the platform tipping points in all countries affected globally. The results of the pandemic have affected platform system worldwide. This study uses the Lotka-Volterra complex system theory Model to develop the complex dynamical model for examining the role of the pandemic towards the platform ecosystem tipping points. In our findings, the results indicate that the ecosystem in major affected economic zones fell quickly after the virus outbreak. The Euro economic zone experienced more negative abnormal platform returns during the critical COVID-19 crisis of 2020-2021 as compared to other economic zones while China affected mostly during the beginning (2019-2020) of the crisis. In addition, the results revealed that, the increase of the foreign direct investment (FDI) enhances the tipping point locations to large values and thus, yields an exponential growth of the platform ecosystem. Furthermore, the study of platform systems is applicable to an optimal control approach to reduce the economic risks, avoid economic collapse and increase platform ecosystem performance.**

Keywords: **Platform ecosystem performance; Lotka-Volterra theory; economic zone; tipping point system bifurcation; foreign direct investment.**

1. INTRODUCTION

Platform ecosystem performance has always been an intriguing research issue and a great challenge because of the complex nature of the problem. Research from the World Economic Forum shows that over eighty percent of executives think that platforms are ‘indisputably the leading form of organizing modern digital markets’ and they stated that, it will be the glue that holds together large groups of users in the increasingly digital market. Many platform complex systems that ranges within the phases (periods) are often at risk of an unexpected tipping to alternative states. Unpredictable disruptions and risk are inevitable facts of life for ecological and platform ecosystems [1, 2]. These economic disruptive events demand that the ecosystem adapt or resist for survival [3]. Ensuing, the concept of improving platform system performance has enacted as a potential alternative to conventional risk management options as applied in other industrial ecosystems [4-7]. A major component of any resilient platform system is the enhancement of adaptive capabilities that allow the system to withstand economic shocks caused by inflation [8] structurally. Even though, conventional risk management strategies have played a vital role to reduce the impacts of specific sources of shocks [9, 10], they cannot extensively cope with platform uncertainties and dynamics. This paper seeks to examine the impact of COVID-19 pandemic outbreak on the platform system. Three-phase period that is before, during the crisis and recovery data was used for this study’s analysis. The logic behind using such data is to investigate how the pandemic perturbation affected the bifurcations by shifting their initial locations towards a state, which is not desirable. Again, the outcomes of this study will make provision for risk mitigation strategy as an adaptive capability [11-13].

Resilience (optimal platform performance) is defined broadly as the capability of a system to absorb economic shocks and reorganize while changing to retain the same function, structure, identity and feedback [14-17]. The ideology of platform performance resilience ensures the fact that every system that is productive will always be subject to unprecedented shocks. From the view of the platform ecosystem, many scholars defined platform ecosystem resilience as a system dynamics that has formed strong resistant adaptation after having experienced unexpected economic shocks [18]. System resilience is a theory originated from socio-ecological studies examined by Huang, Shi [19], is the state of a system to withstand any perturbation structurally, whether predicted, or unpredicted. From this angle, platform makers have instigated resilience strategies into their risk management techniques for many years. Yet, for proper risk management practices like the suggested hedging strategy, applications of system resilience in the platform are still evolving [20]. The relic in the turmoil of the pandemic outbreak, platform sectors need to improve their processes, systems, and technologies to be flexible and meet the ongoing changes in the global market [21]. In recent times, the hardships in economic has led to a high platform ecosystem risk of uncertainty. If these economic shocks become real, they can influence the stock system negatively resulting in deformed. Many researchers have revealed that modern platform systems are at higher risk. [22]

The Pandemic and Platform Tipping Points

Examining and perusing the impact of the COVID-19 on the tipping point area of the platform ecosystem is vital in positioning strategically the critical facilities as network operations strategies [23-26]. In pursuance of this, we instigate the adopted Lotka-Volterra complex system approach [27-29] to examine analytically the underlying the varying platform ecosystem tipping point locations that reveals the degree of the platform resilience during the COVID-19 epidemic. The method examines platform tipping point locations variations for different economic zones. The tipping point variation reveals the zone system's robustness against platform initial loss and the rapidity of the recovery process. In this study, we discuss the background of the COVID-19 pandemic and the tipping point as introduced by [30, 31]. We then explain the notion of predicted platform system's performance behavior as an analytic measure and contributed a simple approach to enhance the platform ecosystem resilience. The resilience value relied on the behavioral patterns of the inflation dynamics.

Historically, the widespread of COVID-19 brought about the most chaotic economic activities crash. The virus that originated in China triggered the economic crash. The COVID-19 case recorded first outbreak affirmed in December 2019 in China, Wuhan city. The virus abruptly spread across the world. The COVID-19 pandemic contagion has shaped an extraordinary situation for our generation, with many nations being affected economically. This situation has led to psychological effects not only for health personnel's and the individuals that got affected from the pandemic but the platform system dynamics also got affected [32]. Adapting to the new situation as suggested by Ashraf [11], Ma [13] can be demanding to avoid the global economic collapse. Recently, other researchers have recommended that emotional trauma during this situation are very similar to grief [33], and some individuals experiencing economic decline on the normal transactions between users in the platform ecosystem, which is liable to dampen the economic growth of sectors like fishing industry exponentially[23].

Due to the growing concern by researchers over the tipping points arising in platform ecosystems because of disruptive events they are facing. A tiny disruptive event in an input condition resulting in huge, sudden, and often irreversible changes in the economic regime of a dynamical system is referred to as "tipping" or "critical transition" point [34, 35]. The abrupt and possibly irreversible shifts between alternative the market system states, potentially incurring high inflation indices is caused by the tipping point. The FDI is central to the inflation feedbacks that regulate the platform performance, as they govern the responses of inflation in platform ecosystem performance that could withstand the shocks. However, little research has been done on the COVID-19 pandemic effects on the occurrence of tipping points. In this study, we argue that the connection between the FDI traded and inflation index should be considered in order to apprehend the balance of feedbacks governing tipping points in platform systems. Furthermore, the platform ecosystem is governed by the developed model that encompasses the mutualistic interaction between one platform firms with others. The platform firm's interaction which is governed by the coefficient of interaction strength β plays a vital role on improving the platform performance by enhancing the tipping point locations to high values and improving the exponential growth of the platform systems.

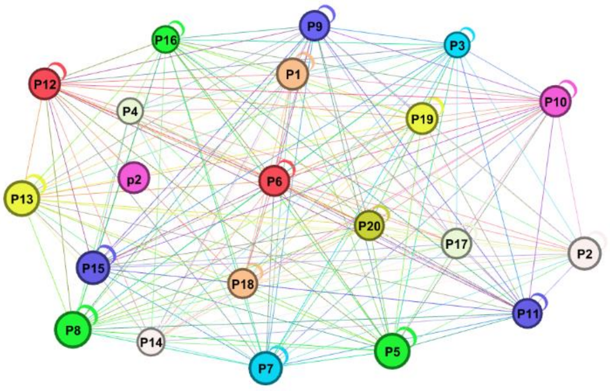

Figure 1: Graphical representation of the platform firms' network

Key: P1-P20 is the 20 platform firms

Source: *Author concept visualization plot*

Simulation tool: *GEPHI*

This paper contributes to the existing literature in ensuring whether the COVID-19 pandemic instigates the decline in platform ecosystem tipping point locations. The presentation is explored in two-fold. Firstly, we applied the adopted Lotka-Volterra system model of the platform ecosystem system dynamics, context introduces the platform ecosystem performance perspective to current risk management literature in this field. Secondly, the outcomes provide empirical valuable insights on risk mitigation strategies in the face of increasingly the inflation index and tipping points drop caused by the COVID-19 pandemic.

The rest of the sections in this paper is arranged as follows. The following section reveals the related literature review, arguments and knowledge gaps. In the third section, we develop the platform system model using the adopted Lotka-Volterra theory system. This section also elaborates on the data and four economic zones under study. The fourth section analyzes and discusses the simulation results. In the final section, we provide conclusion of the study and future recommendations.

2. LITERATURE REVIEW

Ecology has been widely used in recent years as a special research method. In particular, the platform ecosystem theory develops an extensive research domain for researchers and provides brand-new research methods. In virtue of it, researches on platform ecosystem become numerous. Many scholars have researched on the e-commerce and platform ecosystem.

In recent times, the impacts of COVID-19 pandemic on the platform ecosystem have become one of the interesting topics by the recent scholars [36]. The studies associated, in fact, how platform systems affected by the pandemic outbreak challenges as the ability of the latter systems reach a state of no return (equilibrium) after a temporary disruption. In relation to education system, most researchers have argued that the COVID-19 pandemic has had huge toil in the education systems [37]. To alleviate the challenge, researchers further suggested asynchronous learning as an adaptive capability tool. The wide spread of the pandemic across the created the subsequent fear and finally led to the halt of various economic activities [38]. The platform performance responses to the pandemic crisis have differed markedly depending on the infrastructures [39]

The study inculcated Ordinary Least Square (OLS) regression approach, Herwany, et al. [40] aimed to confirm if the COVID-19 pandemic has had an influence on the stock sectors, and how that shakes the Indonesian Stock Exchange (IDX) market returns. Judging from the aggregate value of abnormal returns, the results revealed that, stock markets on the Indonesia Stock Exchange (IDX) were affected by the COVID-19 pandemic. By examining the influence of the rapid spread of COVID-19 on financial markets, Zhang, et al. [31] used quantitative easing (QE) approach to confirm that, the pandemic has created an unprecedented level of risk, causing stock investors to suffer significant loses in a very short period of time. Ashraf [11] examined the stock markets' response to the COVID-19 pandemic. Overall, their results suggested that stock markets quickly responded to COVID-19 pandemic and this response varies over time depending on the degree of outbreak. In a perspective of the US and Canada, the recent studies confirmed that, the COVID-19 pandemic has dragged down the economy at both global and country-specific levels since the beginning of 2020

Other scholars have found, negative market reaction was strong during early days of confirmed cases and then between 40 and 60 days after the initial confirmed cases. Using a structural VAR model, which is adopted to accommodate GARCH-in-mean errors, the scholars further unveiled an unexpected increase in the COVID-19 cases to hurt the stock return with persistence in Canada [41].

In this study, more study that is empirical will be conducted. The research on the complex ecosystem study aims to extend the concept of tipping points on platform ecosystem performance. This is the point shift where to turn back the direction of change will not restore immediately, the level of ecosystem services. Many researchers have carried out study of tipping points of ecosystems in diverse ways to alleviate the risks. Tàbara, [35] presented the notion of positivity of tipping points as property emergent of systems which would allow the fast deployment of evolutionary-like transformative solutions to tackle the present ecosystem problems successfully. Their study deduced how to identify the required capacities, conditions and potential policy interventions which could eventually lead to the development of positive tipping points in various social–ecological systems. In the study of Farazmand et al [12] they stated the ability of linear delay feedback control to curb these tipping points, certifying that the systems stay near a desirable regime. There exist tipping points in social, biological and environment systems and these systems are causally increasing intertwined in the Anthropocene [34].

. In social perspective of tipping point, Bentley, et al. [33] examined the Social dynamics system behavior and their shows that, social tipping points are particularly cumbersome to predict. In complex systems, tipping points are structurally transitioned from one regime shift to another. In platform ecosystems these critical points are connected to systemic risks, which have geared towards financial crisis in the past [42]. In the study of Gualdi, et al. [43] explored the possible types of phenomena that simple macroeconomic Agent-Based models (ABMs) can reproduce. They showed that, there is a generic existence of tipping points between good economies where unemployment is low and bad economy where unemployment is high.

This study is the first to investigate how the COVID-19 pandemic can impact the platform ecosystem performance towards the low state regime by inculcating the adopted Lotka-Volterra complex approach. First, our Lotka-Volterra model system that has been adopted incorporates the FDI, which improves the platform ecosystem towards the tipping points. In addition, it unveils empirically the points to which the system diverts (critical transitions) from a state which is desirable to undesirable state and from which platform managers, policy makers, scientists and regulators can strategically optimize the platform ecosystems to resilient state. Thirdly, we presented mutualistic interaction strength coefficient. This makes the argument in our study robust and innovative in that, the platform users' in the system are accrue a symmetrical benefit. Lastly, platform multi-dimensional complex model is reduced to get one-dimensional which is feasible system for an effective simulation. The rationale behind model reduction is to enhance the efficiency and reliability of empirical outcomes[46, 47]. The combination of all these steps makes the study innovative.

3. MATERIALS AND METHODS

This work adopts the general theory of the complex systems approach[44].This approach highlights platform systems' nonlinear, adaptive, networked and emergent behavior [45]. Hence, we knew system model based on the Lotka-Volterra complex dynamic system approach developed and reduced it from multiple dimensions to one dimension. The stepwise derivation of the platform complex model from formulation to analysis is provided in Appendix B.

3.1 Model Formulation

We developed a new system model for the platform ecosystem performance, based on the Lotka-Volterra model approach. Let $p_i \in \mathbb{R}$ be the growth rate of the platform network at node i at a time t with, assuming that one platform firm has business connections with the other firms. The platform firms are nodes in the networks, and business transactions correspond to edges, as shown in Figure 1. The highest possible platform $K_i(K_i > 0)$ and lowest possible ecosystem growth rate $C_i(C_i > 0)$ with an intrinsic revenue growth rate constant $\alpha_i(\alpha_i > 0)$, as per the logistic model system for this firm, is as follows:

$$\frac{dp_i}{dt} = \alpha_i s_i \left(1 - \frac{p_i}{K_i}\right)\left(\frac{p_i}{C_i} - 1\right) \quad (1)$$

p_i is the revenue growth rate of seller i can also be affected by the inflation index rise γ_i. In this study, we use population dynamics and organizational ecology theories to adopt and examine dynamic systems and platform performance variation. The calculation can be achieved by inculcating the inflation index as an effort parameter and inducing it into Equation (1) to obtain the harvesting effort model [48]. The equation becomes:

$$\frac{dp_i}{dt} = \alpha_i s_i \left(1 - \frac{p_i}{K_i}\right)\left(\frac{p_i}{C_i} - 1\right) - \gamma_i p_i \quad (2)$$

The entire platform system function is determined by the platform ecosystem topology structure where the platform firms are connected. The topology of the system is a weighted using the connectivity matrix that captures mutualistic interactions between platform users (nodes) [49, 50]. Figure 1, exhibits shows how platform users are connected to form a system topology structure matrix $A_{ij} > 0$ of the platform connections. Thus, Equation (2) can be further developed by incorporating the mutualistic interaction term to obtain:

$$\frac{dp_i}{dt} = \alpha_i p_i \left(1 - \frac{p_i}{K_i}\right)\left(\frac{p_i}{C_i} - 1\right) - \gamma_i p_i + \frac{\sum_{j=1}^{N} A_{ij} G(p_i p_j)}{D_i + E_i p_i + H_j p_j} \quad (3)$$

For simplicity, the platform ecosystem configuration can be expanded by introducing the interaction strength parameter β together with applying the Holling type II functional response as suggested by [51] to obtain

$$\frac{dp_i}{dt} = \alpha_i p_i \left(1 - \frac{p_i}{K_i}\right)\left(\frac{p_i}{C_i} - 1\right) - \gamma_i p_i + \frac{\sum_{j=1}^{N} \beta_{ij} p_i p_j}{D_i + E_i p_i + H_j p_j} \quad (4)$$

where D_i, E_i and H_j are parameters that characterize the saturation rate of the response function

$$g(p_i) = \frac{\gamma_{ij} p_i}{D_i + E_i p_i + H_j p_j} \quad (5)$$

The increasing of the foreign direct investments can also promote the exponential growth p_i [36, 52]. We adopted the model system by adding FDI parameter to the platform performance function $f(\gamma, p)$. This can be achieved by incorporating the term m_i into the governing parameter coefficient of the FDI. Thus, the developed model becomes:

$$\frac{dp_i}{dt} = m_i p_i + \alpha_i p_i \left(1 - \frac{p_i}{K_i}\right)\left(\frac{p_i}{C_i} - 1\right) - \gamma_i p_i + \frac{\sum_{j=1}^{N} \gamma_{ij} p_i p_j}{D_i + E_i p_i + H_j p_j} \quad (6)$$

In Appendix B, we detail the steps of our dimension-reduction procedure, which leads to the reduced platform model become:

$$\frac{dp_{eff}}{dt} = m p_{eff} + \alpha_i p_{eff} \left(1 - \frac{p_{eff}}{K_{eff}}\right)\left(\frac{p_{eff}}{C_{eff}} - 1\right) - \gamma_i p_{eff} + \frac{\beta_{eff} p_{eff}^2}{D_{eff} + h_{eff} p_{eff}} \quad (7)$$

The first term of the right-hand side of the Equation (7) accounts for the performance of the platform network at a rate mp_{eff}. The second term describes the effective logistic growth of the platform system with an effective maximum potential capacity K_{eff} and minimum potential capacity C_{eff} and the effective platform performance, according to which for weak performance ($p_{eff} < 0$) the platform ecosystem features negative growth. The third term describes the platform ecosystem collapse at a rate $\gamma_{eff} p_{eff}$ and fourth term unveils platform firms' interaction captured by a response function that saturates

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for large p_i and p_j, indicating that j's positive contribution to p_i is bounded. To construct the estimated β_{eff} which is an effective interaction coefficient, we used the adopted symbiotic interaction relationship [53], collected for financial returns of all platform firms, describing networks ranging from $N = n_1$ to $N = n_2$ nodes where $n_1 < n_2$ and $\{n_1, n_2\} \in \square$.

3.2 Simulation

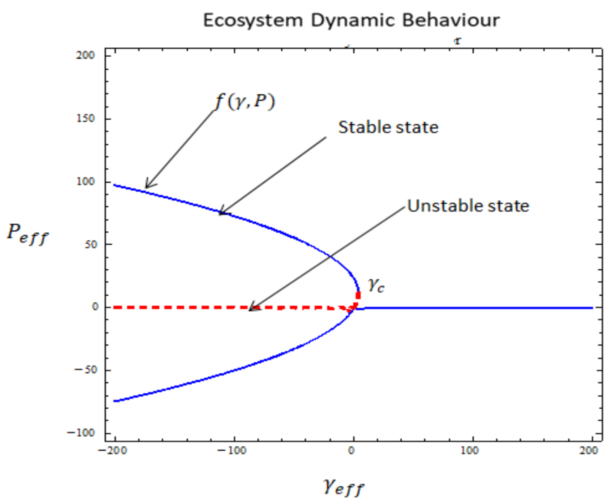
We solved Equation (7) numerically, and tested its resilience under realistic inflation index spikes perturbation, which was caused by the COVID-19 pandemic (Figure 2a and 2b): We took the curated data values of the three-year period that is before, during and after (2018-2019, 2019-2020 and 2020-2021). The logic behind choosing the range of time is to obtain the three distinct features of the stock dynamic behavior at steady state when the system was perturbed to collapse. Lastly, MATHEMATICA and MATLAB mathematical tools were used, we set α_{eff} , K_{eff} , C_{eff} D_{eff} and h_{eff} to investigate the impact of inflation index γ_{eff} towards platform ecosystem performance in the three phase-period.

3.3 Data Structure

The data structure investigates the role of the inflation index during the COVID-19 crisis on the performance of the platform ecosystems. To calibrate the developed model, we took the information of inflation index of all countries across the globe transaction data sources and divided into four economic zones. In this study, we obtained the global FDI values (FDI of all countries across the globe) from 2018 to 2021 (before, during the crisis and recovery), sourced from the global economy database (https://theglobaleconomy.com/). The selected data involve the 2019-2021 COVID-19 outbreak crises, making the study robust. Moreover, all selected member countries collectively comprised 100% of global FDI and inflation index which is beyond the threshold sample size.

4. SIMULATION RESULTS

The software mathematical tools were used to ran platform ecosystem performance function (Equation (7)) on the increasing inflation degree in three consecutive years (2018-2019, 2019-2020 and 2020-2021) to examine the role of inflation index towards the platform ecosystem resilience that is platform ecosystem growth. Results shows the impact of FDI and inflation changes towards the platform ecosystem growth. At $P_{eff} > 0$, the system collapses when the inflation degree rises. On the other hand, the platform ecosystem loses stability to the point of no return γ_c as shown in Figure 2a. This dynamic critical transition in which the system bifurcates (deviates) from stable regime (blue thick line) to unstable state (red line) is called tipping point O_P (Figure 2a, 2b) [30]. This is the point beyond which, the system experiences chaotic behavior (platform ecosystem system collapses completely).



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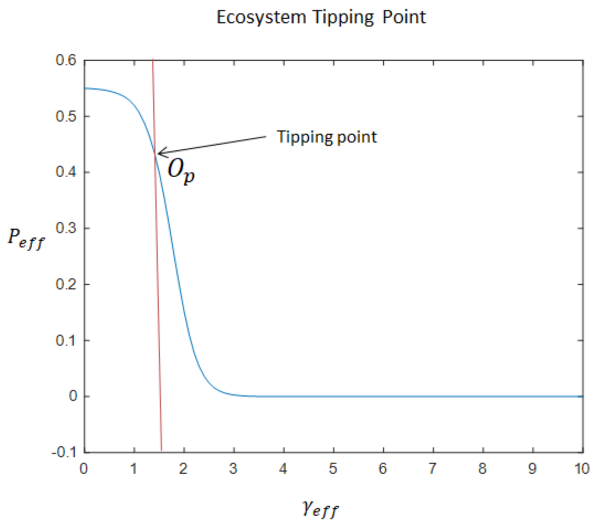


(b)

Figure 2: (a) The platform ecosystem function that shows the critical transitions of the market system

(b) The tipping point location of the platform ecosystem

The results in Figure 3a and 3b unveil the dynamic system behavior of platform ecosystem based on the empirical outcomes. In all the platform ecosystems, the results show that, first, when $P_{eff} > 0$, the platform system experiences two states (stable S, L at $\frac{\partial f}{\partial p_{eff}} < 0$ and unstable U at $\frac{\partial f}{\partial p_{eff}} > 0$).

Furthermore, the results reveal that, in all systems, the increase of inflation degree enhances the collapse towards the tipping point. The location of the tipping point (Figure 3b) (at the intersection between shaded area and the blue line) was varying with the period and market system of different amount of FDI. This indicates that each platform ecosystem experiences different location in tipping point. Second, when $p_{eff} = 0$, all platform systems were at zero stable state where the system is neither growing nor collapsing. Despite experiencing the stable state, the system was less resilient because of the lowest degree of the system growth rate (i.e. $p_{eff} = 0$). Lastly, when $p_{eff} < 0$, the tested results were unrealistic and thus, no conclusion drawn. Moreover, the empirical outcomes of platform ecosystem are discussed in three- phase period (before, during the crisis and recovery).

4.1 2018-2019;Period of no outbreak

In the course of the pandemic, there was no characteristics of such financial crisis. In this period, the platform ecosystem was much flexible with high values of FDI. On the other hand, the price level was not unstable (less inflation) at an extreme value and hence, the tipping points were found at optimal values. These bifurcation point (tipping point) areas were much affected by the FDI amount. The outcome further uncovers that in this period, the global financial zone experienced the most noteworthy tipping point area with $\gamma_c = 6.01\%$ followed by the European zone and China zone both with $\gamma_c = 4.77\%$. The US zone was the economic region with the smallest value of tipping point location with $\gamma_c = 3.44\%$.

In this period, the comes about affirm that, the global financial zone was the most buoyant zone preceded by China and Eurozone zone and the US zone was the slightest flexible system in a sense that, for the global zone to break down totally, has to reach the inflation of $\gamma_c = 6.01\%$ while the US zone subsides entirely(tipping point) at $\gamma_c = 3.44\%$. Furthermore, all financial zones comprising of the global economy encounters an average value of FDI as summarized in Table A2 (Appendix A) which were not surpassing the inflation limits, showing the ideal platform performance.

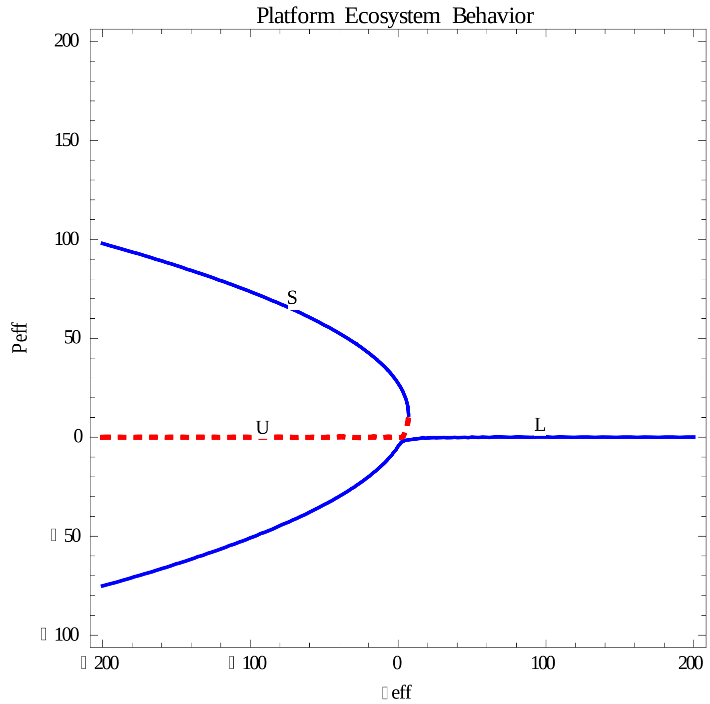
4.2 2019-2020; Period of the COVID-19 outbreak

This was a period in which the outbreak begun to triumph. The results affirm that in the course of the COVID-19 plight within the period of 2019-2020, the global market experienced the rise of inflation degree but for Eurozone whereas their tipping point areas went into well controlled but for China that dropped to $\gamma_c = 3.44\%$ (summarized in Appendix Table A1). This shows that the frameworks were progressing in spite of the COVID-19 emergency but for China that is influenced by the outbreak (i.e. rising inflation whereas diminishing its limit value to which the framework tips). The outcome further reveals the Eurozone to encounter a huge value of threshold inflation degree of $\gamma_c = 16,68\%$ in the time of this crisis. This infers that, Eurozone was the zone that experienced the foremost strong economic region.

4.3 2020-2021; Critical and Recovery from COVID-19 outbreak

This was the period where immunization and other risk mitigations measures were carried out to control the uproar. In this stage there were a few financial regions which begun to recoup (China zone) and others went into grave retardation. The comes about appears that, there was a change of platform system performance for China zone in a sense that, all economic zones dropped in tipping point areas but for China that moved forward from $\gamma_c = 3.44\%$ to $\gamma_c = 4.77\%$. Here we see that, European zone appears the largest critical transition drop from $\gamma_c = 16.68\%$ (2019-2020) to $\gamma_c = 8.79\%$ (2020-2021) followed by the US zone with a decrease from $\gamma_c = 4.77\%$ (2019-2020) to $\gamma_c = 2.12\%$ (2020-2021)

This economic anomaly too happened to Eurozone which experienced the least value of inflation with $\gamma_{eff} = -0.23\%$. On the other hand, the system was dwindle during the dire global crisis in a view that, all the economic zones were still encountering the rise in inflation degree γ_{eff} excluding the Eurozone (2019-2020) economic zone that overseen to control the inflation rise from the Eurozone (2019-2020) economic zone that managed to control the inflation rise from $\gamma_{eff} = 2.58\% > \upsilon_c = 6.01\%$ (2019-2020) to $\gamma_{eff} = -0.23\% < \gamma_c = 8.74\%$ (2020-2021)



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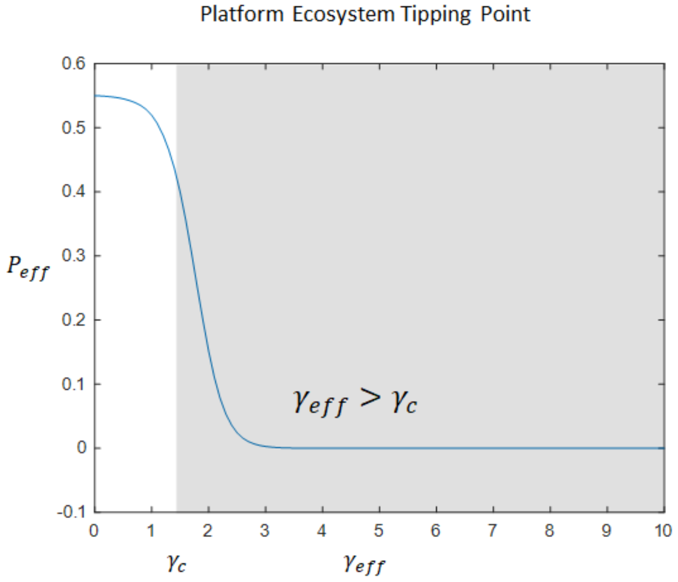


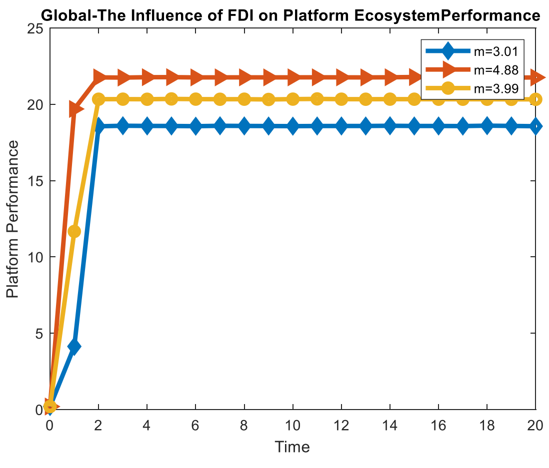
(b)

Figure 3: (a) The critical transitions of the platform ecosystem based on the empirical outcomes.

(b) The tipping point locations of the platform ecosystem based on the empirical outcomes.

The results (Figure 4a-4g) appear that the amount of FDI values improves the platform ecosystem performance by bringing down the inflation degree and making strides the exponential development of the work of the platform system. This infers that, the platform ecosystem gets to be stronger at lower unstable state than at higher unstable state. The results additionally affirm that, all financial zones together with the global economy were encountering more ideal platform performance when the inflation degree was little. In all three stages, the empirical results uncovered that the FDI values were influenced much by the COVID-19 outbreak. Then comes about affirmed this by disclosing the drop of FDI during the critical global crisis. The decrease happened for all economic zones but for China zone that appeared an change from $m = 1.31\%$ (2020-2021) to $m = 1.44\%$ (2020-2021) as exhibited in Figure 4(b). The variation for the other economic zone FDI drop is summarized in Table A1 (Appendix A).

Besides, Euro economic zone (Eurozone) appeared a huge drop in FDI within the period 2020-2021 that went far of the global average drop (Figure 4a-4b). This move suggests that, the Eurozone experienced the state of complete disorder behavior during this stage and gives an early caution for the risk reduction measures to be taken within a short period prior the full platform ecosystem subside occurs. Besides that; the Eurozone in America was the region that experienced the most noteworthy blow within, during this period from 2020-2021.



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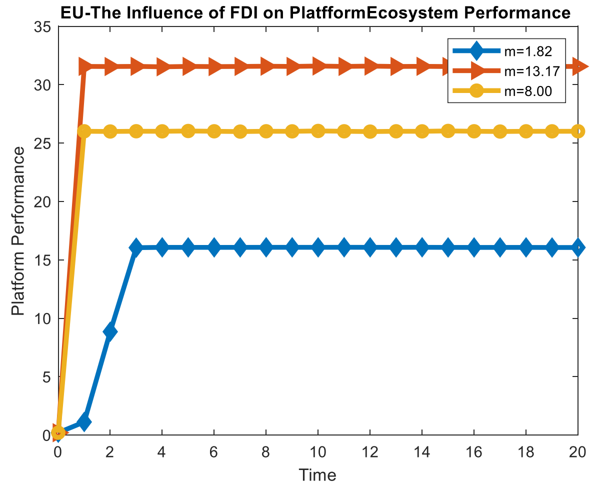

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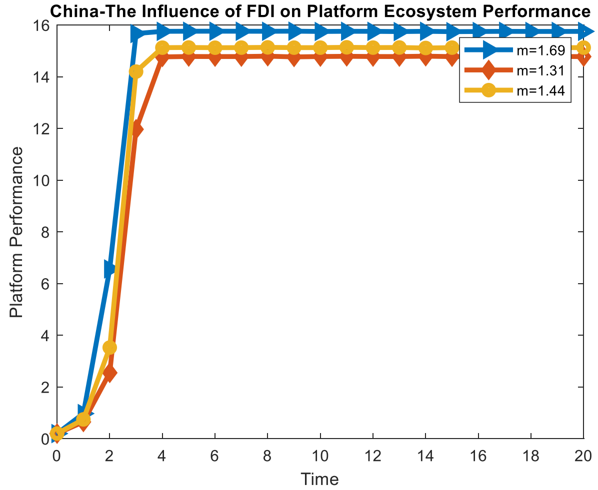

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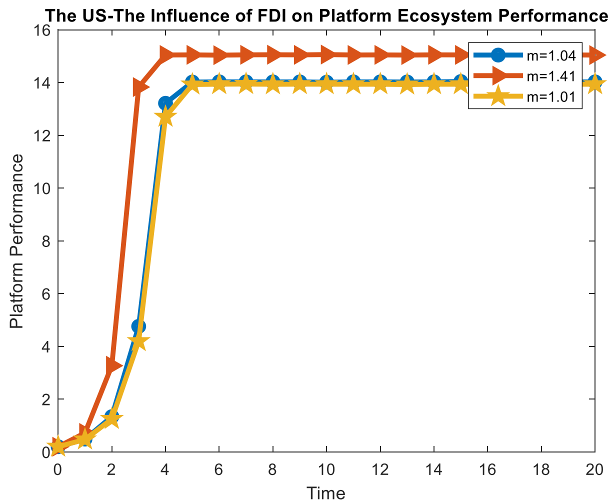

(d)

Figure 4: (a-d): The influence of foreign direct investment on the platform ecosystem performance in the three phase-periods (2018-2019, 2019-2020 and 2020-2021) for four economic Zones.

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5. CONCLUSION

There is a critical effect of the COVID-19 outbreak crisis on the platform ecosystem tipping point area (point of total collapse). This can be said that, the COVID-19 is evaluated as an economic agitation that threatens the platform system performance by diminishing its tipping point areas and curbs the escalation of the performances. This work posits a theoretical framework for analyzing the role of COVID-19 towards the tipping points by exhibiting the three-phase variation of the area in threshold values of the inflation index at which the framework diverges. Our adopted complex dynamic show is based on the Lotka-Volterra system theory. This methodological approach bridges the hypothetical crevice by examining the variation of the inflation degree when the framework subjected to COVID-19 crisis utilizes the Lotka-Volterra complex framework hypothesis. Numerous later researchers examined the Lotka-Volterra ecosystem show on the ecology of plant-pollinator and prey-predator connections [27, 29, 54, 55]. Brodie, et al. [56] pointed out the impact of COVID-19 on the platform ecosystem performance employing a healthcare system approach based on a survey of the service ecosystem. Applying the Lotka-Volterra framework demonstrate hypothesis on the examination of the point to which the stage framework bisects gives the ponder peculiarity.

The outcomes revealed that the platform ecosystem is more conceivably to collide when the systems cleave or bisect at a low tipping point area. In addition, we affirm that the platform ecosystem gets to be stronger at a large sum of FDI. Small degree of FDI employs an enormous negative effect on the tipping point area by bringing down its inflation limit value subsequently activating the platform ecosystem to collapse.

This ponder elucidates a key obligation for economic regulators, managers, and in policy making choices. To begin with, from an ex-ante point of view, policy producers, economic managers and controllers can progress the performance of the platform ecosystem by controlling the degree of the expansion index rise and the tipping point areas. This enhancement can be accomplished by boosting the amount of FDI as carried out by China amidst the critical plight of 2020-2021 in which it progressed, whereas the rest of the zones were subsiding.

This aftereffect will make the platform ecosystem vigorous and centered on combating the economic collapses caused by the COVID-19 flare-up plights. This work plays a part in an inherent and simple way to distinguish the inflation degree that can thrust the platform ecosystem towards tipping points collapse. Hence, policymakers and regulators can suggest a suitable methodology as a framework control strategy. We trust that our embraced Lotka-Volterra framework model approach will trigger the intrigued of future economic scholars from different disciplines. The theory approach incorporates examining the impact of the inflation index and FDI values on the system performance. By utilizing this ponder, future analysts will have a more profound understanding into monetary and other global economies.

Appendix A: Data Based Empirical Values

Table A1: The calculated and simulation economic zones-specific values of inflation index γ_{eff} and corresponding threshold values γ_c during the COVID-19 outbreak

The Values of Inflation Index (γ_{eff})						The Values of Inflation Index Critical Transitions (γ_c)			
Economic Zone	**Year**	2018-2019	2019-2020	2020-2021	Economic Zone	**Year**	2018-2019	2019-2020	2020-2021
	Global	3.91	4.82	7.68		Global	6.01	8.74	7.42
	Euro	2.58	-0.23	1.43		Euro	4.77	16.68	8.79
	China	1.00	2.40	2.90		China	4.77	3.44	4.77
	The US	2.40	1.20	1.80		The US	3.44	4.77	2.12

Source: *Author computation*

Table A2: The calculated economic zones-specific values of FDI (m) during the COVID-19 outbreak

The Values of FDI (m)				
Economic Zone	**Year**	**2018-2019**	**2019-2020**	**2020-2021**
	Global	3.01	4.88	3.99
	Euro	1.82	13.17	8.00
	China	1.69	1.31	1.44
	The US	1.04	1.41	1.01

Source: *Author computation*

Appendix B

- **Model Reduction**

Taking Equation (7), our derivation process is based on the assumption that the carrying capacity K_i for all seller-nodes $i = 1, 2...n$ has an identical value: $K_i \cong K_{eff}$ which is similar to, $D_i \cong D_{eff}$, $C_i \cong C_{eff}$ and $\beta_{ij} \cong \beta_{eff}$. The basic idea of dimension reduction is to feature the platform network's configurations by determining an effective dynamical parameter [57, 58]. This calculation can be achieved by having an approximate manipulation as

$m_i p_i \cong mp_{eff}$, $\alpha_i p_i \cong \alpha_{eff} p_{eff}$, $\gamma_i p_i \cong \gamma_{eff} p_{eff}$ and $p_i s_i \cong h_{eff} p_{eff}$ where p_{eff} is the effective growth rate of the platform return (platform performance). By combining all these reduced terms, the Equation (6) becomes an effective Equation (7).

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