Open Peer Review on Qeios

Clusters of Small and Medium-Scale Enterprises – Resources and Economic Performance

Oluwabunmi Falebita[1], Saroj Koul[2], Ivan Taylor

1 Bowen University
2 O.P. Jindal Global University

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

Purpose: This study investigates the interaction among small and medium enterprise (SME) clusters, resources and sustainable economic performance in the Electronics Industry of India. Specifically, this study seeks to: investigate existing cluster drivers for and against business growth, examine the interactions among SMEs within the cluster, and quantify the multidimensional effects of resource changes on SME clusters.

Methodology/Approach: We have developed a calibrated and validated System Dynamics (SD) model of an SME cluster to understand the forces at play, test various scenarios and introduce system-wide shocks. Time-series data were obtained from the Government of India websites to inform the SD model and ensure accurate parameter estimates and predictions.

Results: The empirical findings reveal the drivers of business clusters and quantify the multidimensional effects of changes in resources on SME clusters. Growth was observed, but it was not sustainable despite implementing the new policy. The optimal resource additions necessary for stimulating the growth of SMEs and reversing the decline were revealed. Additional infrastructure and financial resources investments are projected to reach a point of diminishing returns by 2030.

Limitations: The current model excludes the lifecycle of SMEs and the impact of the growth in "additions to resources per year". Determining other controllable influencers of location-based SMEs needs to be considered.

Practical and societal implications: To the best of our knowledge, this model is the first validated SD model of the location-based SME cluster. The SD model could inform us of practical policy approaches for the success of the SME clusters in India and the developing world. The study recommends optimal resource additions for reversing the declining SME in the cluster. Thus, this work fills a crucial methodological gap in the study of SMEs.

Keywords: SME Cluster; Electronics sector; Financial resources; Government policies, Human resources; System Dynamics; System Modelling.

1. Introduction

1.1. *Definition, Global Clusters, Developing country Scenario, Indian Scenario*

Clusters are groupings of closely related industrial units restricted to a region (**Delgado et al. 2014**) and recognized as the strategic drivers of competitiveness, innovation, and, consequently, jobs and development (**Porter**, 1998; **Bakarić**, 2017). In addition, literature has shown that industrial clusters possess the potential to increase enterprise competitiveness and productivity, contribute to innovation, create jobs, and enhance new business formation (**Bhamra & Kishore** 2022**; Bylok** et al., 2016; **Bakarić**, 2017).

Clusters have become a critical part of most nations of the world. Governments tend to play a prominent role in driving cluster growth by including a "cluster growth strategy in their current economic development plans" (**JP Morgan Chase** & **Co.** 2014). Countries like Germany, Mexico, Scotland, and Sweden concentrate on cluster development (**Teekasap**, 2009). Silicon Valley, USA, is a viable example (**Delgado et al.,** 2014). The popularity of these arrangements grew after UNIDO and OECD applied the "concept of clusters" as a tool for development (**UNIDO, 2009; OECD, 2005**). As such, clusters and cluster structures have been in place in developing countries, including India and Nigeria and are associated with "Micro, Small and Medium Enterprises (MSMEs)."

Much of the definition of clusters has been attributed to Michael Porter (**Cavén**, 2011). According to **Porter** (1998), business clusters geographically localized often demonstrate a substantial competitive advantage and increased productivity and product innovation. Competitive advantage is the management of the overall value chain of a firm, encompassing the suppliers, distribution channels, and customers.

Clusters can influence both positively and negatively the socio-economic growth, and the factors are the players (**Menzel & Fornahl**, 2010), networks and institutions (**Ter Wal & Boschma**, 2011) that "influence the emergence, growth, decline and transformation of enterprise clusters" in any region. The interaction in a complex system requires dynamic modelling over the life cycle of any cluster and the principles of adaptive management to cope with an evolving knowledge base (**Fornahl et al.,** 2015). However, there is a need to establish the relationship between clusters, innovation capability and business performance (**Europe INNOVA 2008; Temouri, 2012, Tsakalerou, 2015**).

Nevertheless, the accuracy of the role of clusters within the SMEs concerning business growth in developing countries requires a system-based investigation. **Kurniasih et al. (2023)** highlights the relevance of system dynamics approach as a significant technique for supporting the attainment of sustainable MSMEs through modelling and simulation of various influential factors. Hence, this study unveils the potential impact of the electronic industry's cluster-based SMEs on business and economic growth through a comparative evaluation of the multi-dimensional interactions among the cluster drivers by taking the case of India.

This study seeks to achieve the following objectives:

i. Identify, investigate and categorize existing cluster drivers for and against business growth,
ii. Examine the causes and effects of interactions among the SMEs within the cluster, and
iii. Using system dynamics, quantifying the multi-dimensional effects of resource changes on SMEs' clusters.

2. Literature Review

2.1. *Clusters and Economic Growth*

Nursyamsi et al. 2018 argue that clusters have been topical in economic analysis, and research around this concept has been going on since **Porter**'s work (1998). Porter (1998) defines clusters as a contiguous collection of interrelated enterprises, contractors, and organizations related through differing externalities (**Ekeh**, 2017). Clusters have also been perceived as an assemblage of "SMEs (Small and Medium-scale Enterprises)" within a given locality, sharing common facilities, including electricity, water, and access roads. Furthermore, according to **Delgado et al. (2010)**, another formal definition of the cluster is "an assembly of closely allied businesses functioning in a specific area." Thus, clusters may exist at different levels, such as the neighbourhood, city or region.

Furthermore, clusters go through different developmental phases, regarded as a lifecycle. The clusters' lifecycle comprises four phases (emergence, growth, maturity, and decline with probable renewal) (**Njøs and Jakobsen, 2016)**. Hence, recent studies have recognized the importance of formulating tailor-made policies for application to different life cycle phases.

Clusters represent a specific competitive asset of regions, creating a solid foundation for economic growth **(CIC, 2019**). Furthermore, globally, cluster development is perceived as the most effective industrial strategy to aid SMEs growth, regional development and employment creation (**Feldman et al., 2005).** They also represent creating trading opportunities, attracting soft loans and foreign investments, increasing productivity, enhancing import substitution, and promoting export and innovation upgrades. In the case in China, it has led to reduced production costs and yielding competitive products in price and quality. As a result, Silicon Valley, Modena, Sweden, Denmark, and some developing countries have adopted the concept of industrial clusters as a prominent driver of regional and national economic growth (**Ekeh, 2017).** Other benefits attributable to clusters include interrelationships (market, technological, infrastructure, procurement, finance, innovation and R&D), large-scale networking, joint lobbying, and political power. Some other inherent benefits of clusters, such as innovations, development of foreign markets, reduced financial requirements, and the spread of risks among enterprises that lower failing enterprises, have also been identified (**Čolović et al. 2016**).

According to **JP Morgan Chase & Co. (2014**), the coexistence of enterprises as clusters lead to increased production stimulates novelty, and fosters new business creation. Hence, it can significantly impact small enterprises' continued existence and progress (**Delgado, Porter, & Stern, 2010**). Moreover, clustering engenders economies of scale among SMEs, increased productivity, employment, collaborations, and worldwide competitive advantage (**Čolović et al. 2016**). Furthermore, **Nursyamsi et al. (2018)** opine that governments should play essential roles in developing clusters,

improving clusters' quality, and assessing the important indicators of clusters, qualitatively and quantitatively. For example, qualitative indicators could include trust and coordination, economic impact, relationships between companies and research institutions, and policymakers. In contrast, indicators for qualitative assessment of clusters include economic growth, Gross Domestic Product, human resources, amount of enterprises in clusters, to mention a few. The greater the number of players in a cluster, the greater the strength and relationship among their qualitative and quantitative measures.

The success of clusters depends on several factors. It includes clearly defining clusters, creating industry policy to support clusters, fortifying the demand-pull sector, eliminating scams, stimulating trade and globalization, bolstering novelty, R&D, and strengthening education and workforce. **Madaleno, Nathan, Overman, & Waights (2018)** argue that increased attention has been placed on clustering and cluster policies to understand and exploit geographic concentration. They also opine that geographical concentration represents expediting creativity, ideas exchange, and positively contributing to innovation and entrepreneurship. The sustainable development of MSMEs according to **Kurniasih et al. (2023)** is significant for strengthening and enabling economic growth, improving citizens' welfare, effective allocation of resources and managing environmental impacts. Hence, developing industrial clusters could contribute to SMEs' growth and reduce the unemployment rate.

2.2. *Micro, Small and Medium Enterprises (MSMEs)*

MSMEs occupy a significant position in many nations, from creating jobs to improving living standards significantly. They are also responsible for stimulating innovation, local capital formation, job creation, economic development, and competition in developing economies (**Darussalam Enterprise [DARe] 2017**). Nevertheless, attaining sustainability and growth among MSMEs is bedeviled with many challenges due to the complex and dynamic interdependencies (**Kurniasih et al. 2023)**. Various governments at different levels undertake numerous initiatives to foster the growth and development of MSMEs. Their development now forms an essential component of the national vision. It includes establishing national bodies supporting MSMEs in India, Nigeria and Brunei (**SMEDAN/NBS, 2013; DARe 2017; Make in India, 2021**).

Furthermore, the influence of government policy and measures on the development industries is significant as highlighted by **Katti & Mujumdar (2022).** They showed the impact of government policy measures on the cluster of SMEs in the automotive component industry in Pune, India. They revealed that regulatory measures have more significant impact for medium enterprises than small enterprises, while operational policies had equal effect on medium and small enterprises. In addition, an assessment reveals that MSMEs represent a vital force in driving innovation and economic development, about 90% of businesses across the globe are MSMEs and are responsible for around 80% of new jobs. Also, all such benefits derived from the accumulation of MSMEs together as clusters identified (**Navickas & Malakauskaitė 2009; Bylok et al., 2016**) are in **Table 1**.

Table 1. Some Benefits derivable from the clustering of MSMEs

Derivable benefits
1. Enhanced productivity 2. Improved innovation 3. New job creation and increased employment opportunities 4. Facilitation and creation of new businesses 5. Benefit from trade, interdependency and interrelations, and share resources 6. Knowledge sharing leads to advancement in technical, financial, R&D, and marketing knowledge 7. Accessibility to external resources and sharing internal resources by similar companies 8. Transfer of information flows rapidly among business entities in clusters 9. Heightened competition among businesses in clusters 10. Reduced cost of operation in clusters due to economies of scale 11. Ensuring access to new technologies and spread of new and emerging technologies 12. Potential increases the human capital's volume and value/quality 13. Financial benefits through loans 14. Increased specialization

Source: *Modified by authors [Navickas & Malakauskaitė, 2009; Bylok et al. 2016]*

2.3. *MSMEs in India*

During the last fifty years, MSMEs and clusters have surfaced as a growth sector of the Indian economy. They have complemented industries of large size, both in the backwards-and-forward linkage and provided extensive employment opportunities in the country, thus contributing to socioeconomic development while ensuring a regional balance on industrial progress (**Das and Das, 2014**).

The **MSMED Act 2006** revamped sectoral-level policy issues, including the investment ceiling**(MSME Samadhaan, 2006),** thus facilitating enterprise development and competitiveness. In 2014, the GOI unveiled a program of regulatory reforms under its **'Make in India'** package. The related business regulation comprised: creating an enterprise, handling building licenses, accessing electricity, receiving loans, international trade, and dealing with bankruptcy. The efforts yielded modest results, and India ranked at 63rd position from the earlier 79th ranking in "Ease of Doing Business" amongst the chosen 190 countries.

Although MSMEs in India face several risks despite being recognized for their dynamic performance,**Bhamra & Kishore (2022)** using the grounded theory approach, highlight relevant strategies for MSME clusters in Gujarat, India to scale-up and become competitive. Deterrent to the cluster growth includes limited investment capability, low production capacity, difficulty in redirecting skilled personnel to undertake process re-engineering initiatives and the unavailability of suitable planning tools. In addition, the absence of adequate and timely resources, limited capital, limited know-how/capability, non-availability of suitable technology, restraints on modernization/expansions, low-productivity, high cost of infrastructure, non-availability of skilled labour at affordable cost, competition, non-identification of new markets, adequate follow-up with government agencies are other constraints (**Das and Das, 2014; MSME, 2019**).

2.4. *Application and Use of System Dynamics Approach to Clusters and SMEs*

The system dynamics approach enables modeling and simulation of feedbacks and interrelationships among factors that

influence systems including sectors of MSMEs' (such as tourism, steel, manufacturing and steel industry) as highlighted in the review conducted by **Kurniasih et al. (2023). Marafioti et al. (2021)** developed a calibrated SD model to examine the long-term effects of internationalization policies of machinery producers in industrial clusters. They highlighted the need to develop the clusters' lifecycle and the consequences of clusters' internationalization by exporting technology, new knowledge, and collective innovation. In their recent research, using SD Model scenarios, **Suryani et al. (2020)** enhanced MSME market share and profitability through social media strategies, while **Cosenz & Bivona (2021)** modernized SME characteristics through a lean strategy design tool.

Shakib (2020) developed a conceptual SD Model to investigate developmental policies using an exhaustive list of factors identified from published documents and interviews influencing Tehran's Furniture Industrial Cluster. Some factors include "cluster size, suppliers, staff, market demand, production capacity, training, and investment." Results indicated that the cluster becomes more substantially viable by varying policies such as expanding production capacity or decreasing lead time, or according to low-interest governmental loans, thereby creating a competitive advantage for the firms in a cluster in a country. As cluster policies spread through the world's regions to promote "employment, innovation, and entrepreneurship," **Rocha et al. (2020)** attempted an SD Model for clusters' economic and social dynamics. The model depicted that "positive economic performance does not necessarily lead to regional social cohesion."

Again, to enhance the competitive advantage of SMEs, including the determinants of environmental conduct becomes necessary. Therefore, **Fonseca et al. (2020)** combined the fuzzy cognitive mapping techniques with an SD model to analyze environmental conduct in SMEs, with results validated by the "Institute for the Support of Small and Medium-sized Enterprises and Innovation" (**IAPMEI** in Portuguese). The dual methodology empowers SMEs to analyze the consequences. While long-term sustainability is vital for the growth of family businesses, overcoming internal and external obstacles becomes critical. Using the same dual approach, the model Marques et al. (2020) developed allows for a holistic assessment of "the family business growth, cause-and-effect relationships, and long-term behaviour." For the validated SD model on competitiveness relationship**, Martínez-Marín et al. (2020**) conclude that factors revolving around "innovation, production, financial, organizational, commercial, and cluster management" enhance the cluster competitiveness.

Moreover, using SD modelling**, Uriona & Grobbelaar (2019)** assessed the ISO 50001 certification over 2016-2040. While financial and fiscal incentives significantly impacted the promotion of greener standards and initiatives, their model offered several suggestions for adopting energy management systems by the industries in the cluster. In the same way, **Zhang (2019)** correlates the industrial cluster effect at the Qingdao Port, China and reveals that cluster development of port trade positively affects the regional economy.

SD modelling was combined with agent-based modelling by**Schwab et al. (2019**) to conduct a "longitudinal empirical study." Their study appraises financial sustainability by effectively managing financial KPIs. Furthermore, **Vojtko et al. (2019),** emphasizing the dynamics of crises in manufacturing SMEs, developed an SD model showcasing "company life cycles, crisis management, resilience, and business continuity" in the Czech Republic. Furthermore, **Haghighi-Rad et al. (2019)** utilized the SD approach to test an Iran company's business success while counting the SME performance model.

In addition, they proposed the establishment of a customer network before production to increase the organization's chance for success. Also, for factors tricky to quantify, **Zhou et al. (2019)** proposed a cloud-based sub-model to determine the SD model's parameters for the Shenyang economic zone through an interactive display for the industrial logistics clusters and their urbanization.

Earlier, **Anufriev & Holodov (2018)** modelled the functionality of interconnected regional enterprises of construction clusters - a localized and decentralized socio-economic system. Through an established SD model**, Zheng & Huang (2018)** considered three factors: "technological diffusion developments, sluggish message sharing, and an unstable market," indicating that the cluster with a favourable technology manages innovative technology to become competitive. Also, to understand the transshipment policy, **Yan & Liu (2018)** simulate industrial cluster supply chains. The proposed model improves customer satisfaction and decreases the total inventory.

Building on the vast literature on SME clusters and cluster-based strategies,**Venugopal et al. (2018)** identified different advantages in a typical cluster. They examined how they may boost competitiveness, resulting in sustainability. **Nursyamsi & Moeis (2018)** assembled an SD model for the Indonesian maritime cluster. They discovered that the growth rate of employment and the maritime economy are much more significant with a cluster effect, implying that the government should legitimize maritime clusters to promote the industry's performance. In another application, **Hristoski & Kostoska (2018)** simulated using an SD model, the Networked Readiness Index (NRI), based on the 53 indicator values/scores on the clustering of countries in Macedonia, thus examining the country's potential to improve its global rankings.

Kotturu & Mahanty (2017) explore "competitive priorities, key factors, and causal relationships influencing SMEs to enter global value chains" in Indian automotive component manufacturers. Their survey exhibits "product quality standards as the essential priority for joining global production networks, followed by price competitiveness, timely delivery, innovativeness, manufacturing flexibility, service, and dependability". The qualitative findings proclaim "continuous personnel training, capacity expansion, and research development", as the other significant factors influencing competitiveness. Similarly, cluster study from developed and developing countries, including India, by **Saha et al. (2011),** reveals that joining clusters sustain competitive advantage and enrich regional economic development. Moreover, sharing strategic information increases the innovative capabilities of the clusters, thus enabling them to survive in this competitive world.

Also, in the previous decade, SD models in the domain of MSMEs exhibit cluster growth as a cognitive and organizational understanding (**Dangelico et al., 2010**), or considered factors include "resources, workers, jobs, unemployment, salary, market demand, and production capacity" (**Teekasap, 2009**). Similarly, to assess the impact of the cluster approach on SMEs' competitiveness, Lin et al. (2006) established "manpower, money, technology and market flows" as significant factors to positively affect the industrial cluster impact vital in defining a regional competitive advantage.

Cluster policy positively affects SME policies in industrialized economies; however, such effects are not yet been researched in developing countries. The next section attempts to develop a calibrated and validated SD model of an SME

cluster in a developing economy to understand the forces at play from an endogenous feedback perspective. The resources used (**Table 1**) include financial, infrastructure, and human resources. The current model is implemented in Vensim™, for which time-series data to inform the SD model were obtained from the Centre for Monitoring Indian Economy Pvt. Ltd. **(CMIE, 2021)** and the Government of India websites. This SD model was calibrated and validated to ensure accurate parameter estimates and predictions.

3. Methodology

3.1. *System Dynamics*

System Dynamics (SD) is an approach that works based on understanding the underlying feedback mechanisms of a complex system and its function. It "is a modelling methodology used to analyse and critically assess the behaviour of dynamic complex systems based on causal relations and feedback loops, which enable generating plausible scenarios" (**Sterman, 2000**). It functions based on the knowledge of the system monitored over time. It originated from the work of Jay W. Forrester (1960), an MIT researcher on dynamic system modelling. According to **Richardson (2011),** "this methodology combines numerous approaches, including computer simulation, strategic decision-making, and understanding feedback in a complex system". As a result, system dynamics has become an effective tool for policy analysis, such as energy development policies, eco-agriculture policies, and cluster creation policies **(Li *et al.* 2012; Teekasap, 2009).** This dynamic model considers a closed system, the feedback effect, main variables, and success parameters for model development (**Nursyamsi and Moeis, 2018)**.

System Dynamics is ideally suited for analysing a system monitored over time because it is based on calculus; in particular, the system is modelled as a highly interconnected system of first-order differential equations with boundary conditions solved using numerical methods. Furthermore, the model used in this study was formulated based on a well-known behaviour in systems called *overshoot-and-collapse,* in which a population exploits the resources in its environment until it eventually exceeds the environment's carrying capacity, which causes the population to collapse. This behaviour was observed in the SME clusters examined in the case studies discussed in the following sections.

3.2. *Data Gathering*

Primary data (from the Centre for Monitoring Indian Economy (CMIE), Government of India (GOI) website) on enterprise clusters with particular attention to the developing countries (taking the case of India) are obtained from relevant sources and stakeholders (government agencies, private organisations, published business journals, textbooks, the internet and unpublished works). The system dynamics methodology monitors the complex interactions of the factors for and against business growth in the developing world. The 2006 and 2018 policy options for SMEs in India were considered. The clusters considered in this study comprise MSME in the Electronics Industry, and the model was tested in India's Maharashtra and Delhi regions (**CMIE, 2021).**

3.3. *Model description*

The model was created in the special-purpose programming language Vensim (www.vensim.com). One can formulate the System Dynamics model by entering the appropriate equations in the graphical interface. The software will develop and solve the series of highly interconnected integral equations with initial conditions using Euler integration. For example, this model consists of four interconnected integral equations for SMEs in the cluster and one for each of the most important resources for attracting SMEs to the cluster and sustaining the SMEs in the cluster: infrastructure, financing, and human resources.

Figure 1 shows the structure of the SME in the cluster sub-model. We begin with an initial number of SMEs in the cluster, and then over time, the number of SMEs in the cluster changes based on SMEs joining and leaving the cluster. The number of SMEs joining the cluster is calculated as the current number of SMEs in the cluster times the joining rate. The joining rate is based on a normal joining rate times three multipliers based on the impact of the three types of resources (infrastructure, finances, and human resources). The number of SMEs leaving the cluster is based on the current SME in the cluster divided by the SME life span. The SME life span is calculated as the normal SME life span times three multipliers based on the impact of the three resources.

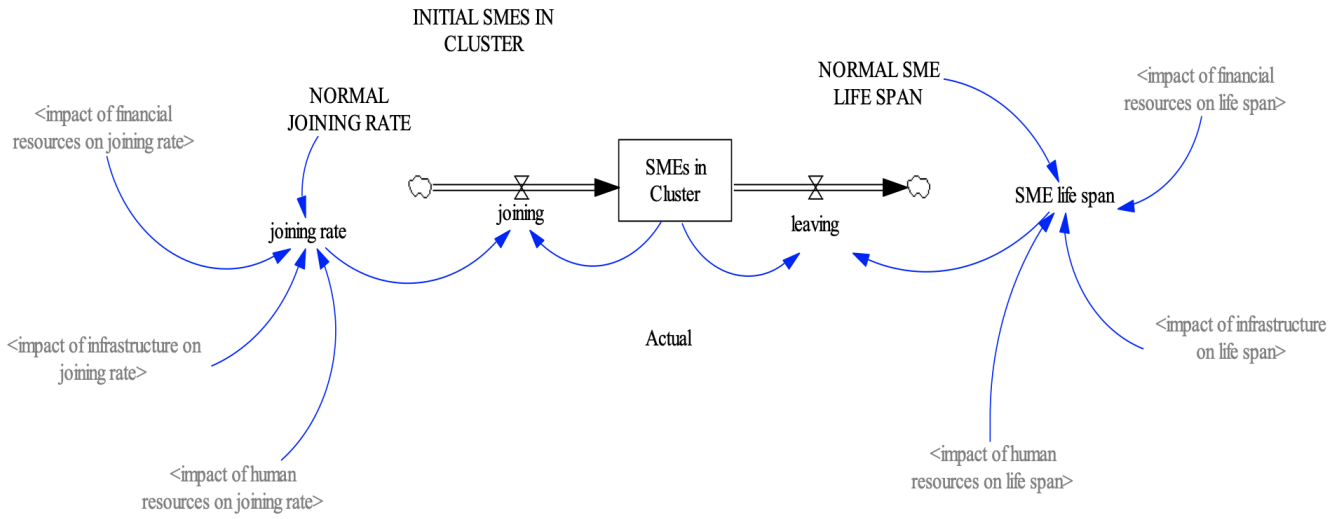

Figure 1. The SMEs in Cluster Model

There are three identical sub-models for the three resources, infrastructure, financial, and human resources. Each has the same structure, as shown in **Figure 2**. Each resource starts with an initial value and then changes over time based on additions to the resources and consumption. The additions are based on national government policies that promote the SME clusters' development. It is assumed that each region in India has an initial endowment of resources, and before implementing the 2006 policy, each region had a specific number of additions to each resource. Afterwards, there were new annual additions to the resources.

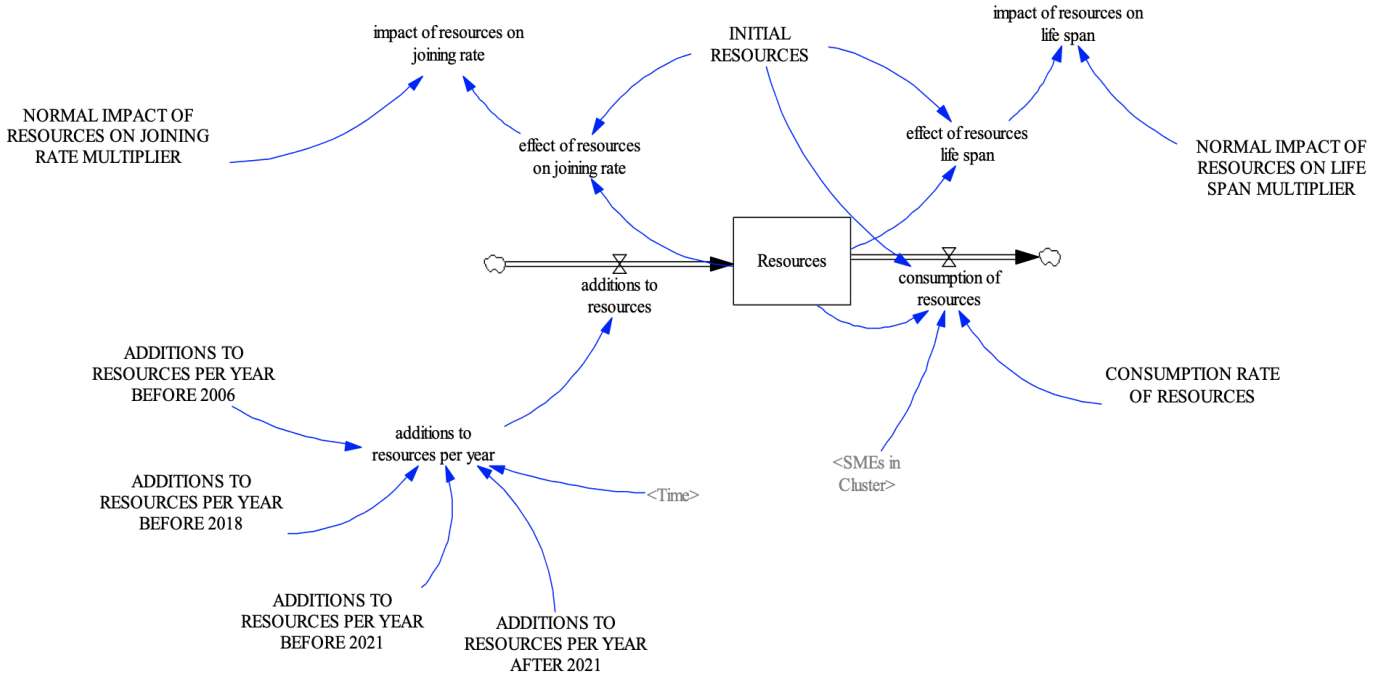

Figure 2. Cluster Resources (Financial, Infrastructure, and Human)

The impact of the resources on the joining rate and the life span of the SME is calculated as the current number of resources divided by the initial level of resources times the normal impact of the resource on the joining rate and the life span. Then these impact values for the three resources are used in the SME in cluster sub-model to modify the SME joining rate and life span.

4. Findings

4.1. *Identified Existing Cluster Drivers affecting business growth*

Table 2 contains the existing cluster drivers identified and categorised from the literature that could work for or against business growth. These drivers comprise three categories - influence business growth/decline, characterise the SME clusters, and typify technological changes/ innovation. The business growth/decline category represents the variables whose interactions can contribute to business growth/decline. The SME cluster category comprises those factors that are representative of the cluster. In contrast, technological change is the factor that represents technological advances and innovation employed by the SME in the cluster to improve their transacting business.

Table 2. Existing Cluster Drivers for and against Business growth

Business growth/ decline	SME Cluster	Technological Changes/ Innovation
% contribution to GDP	Infrastructure; power, road, sanitation, buildings, water supply, security and safety	Use of mobile phones
% Demand	Cluster size	Internet
Turnover/sales volume	Cluster location	Computerisation
Market share	Cluster space	Mobile apps
Profit/profitability	Cluster productivity	Transfer mode of payment
Customer base	Number of MSMEs in the cluster	Online banking, ATM, POS
Capital	Number of cluster employees	Credit/ loans/finance
Production capacity	Cluster prices	

Modified by authors [Nursyamsi and Moeis (2018); Dragičević and Obadić (2014)]

4.2. *SME Patterns for Maharashtra and Delhi Regions*

The best practices in System Dynamics modelling emphasise the need for validation. This model was validated by calibrating the model results using time-series data from the Centre for Monitoring the Indian economy. This study was conducted for two case studies in the Maharashtra and Delhi regions. Data from all the regions of India were collected, but these two regions were chosen for our case studies because of their large sample of SMEs. The data from the other regions showed a similar pattern of behaviour but had smaller numbers of SMEs. The validation entailed collecting time-series data on the number of SMEs in each cluster, with the number of SMEs joining and leaving each year from 1994 to 2020. After that, the parameter values were estimated to minimise the sum of squared error that provided the best match between the time-series data and the model results.

Figures 3a, 3b, and 3c show the calibration results for the Maharashtra region, while **Figures 3d, 3e and 3f** show the results for the Delhi region. It is shown that after implementing the 2006 policy, there has been rapid growth in the number of SMEs in the clusters. However, the growth is not sustainable in the long term. Hence, around 2014, the number of SMEs leaving the cluster became greater than those joining. This is the familiar overshoot-and-collapse pattern often seen in the System Dynamics literature **(Ford, 2019)**. So, the national government introduced the 2018 policy. But, conversely, this 2018 policy did not stop the decline.

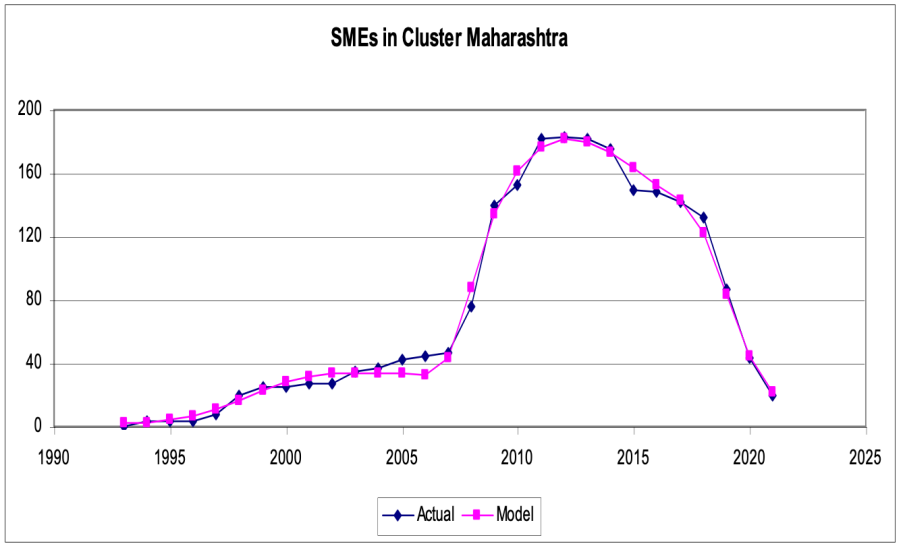

Figure 3a. SME in the Cluster: Maharashtra Region

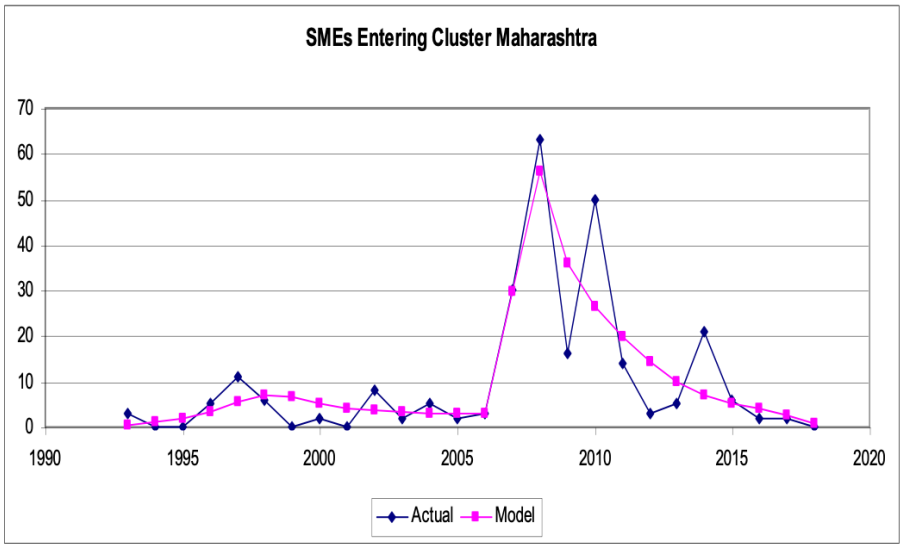

Figure 3b. SME Joining the Cluster: Maharashtra Region

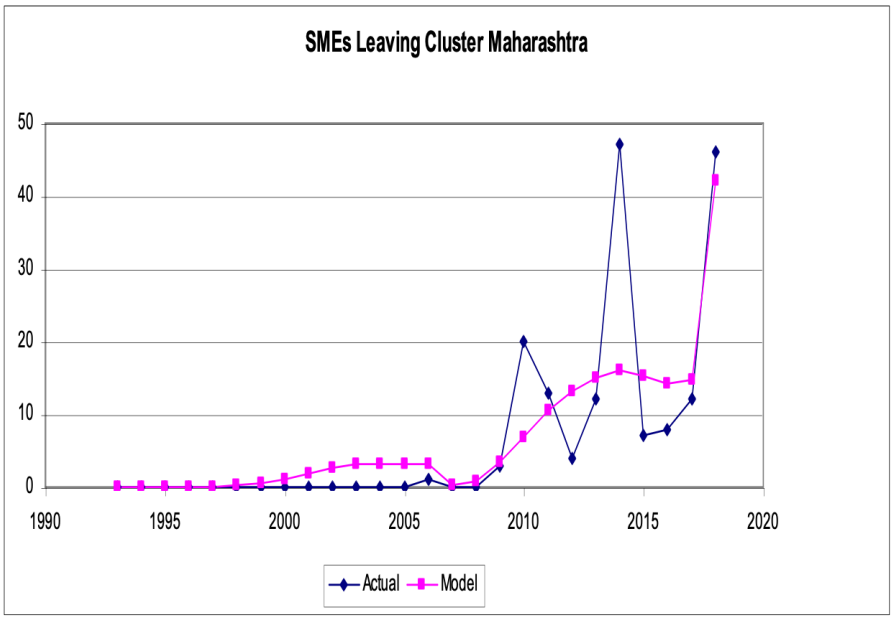

Figure 3c. SME leaving the Cluster: Maharashtra Region

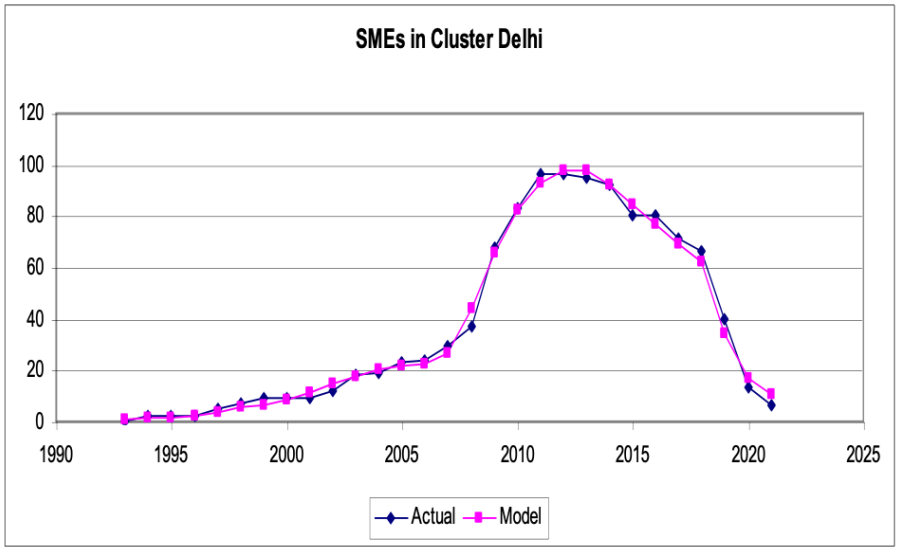

Figure 3d. SME in the Cluster: Dehli Region

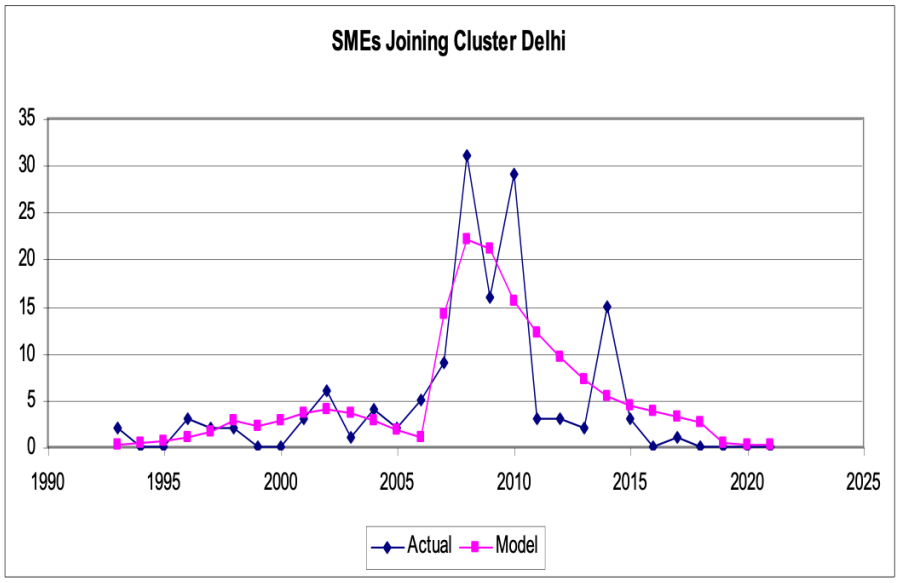

Figure 3e. SME Joining the Cluster: Delhi Region

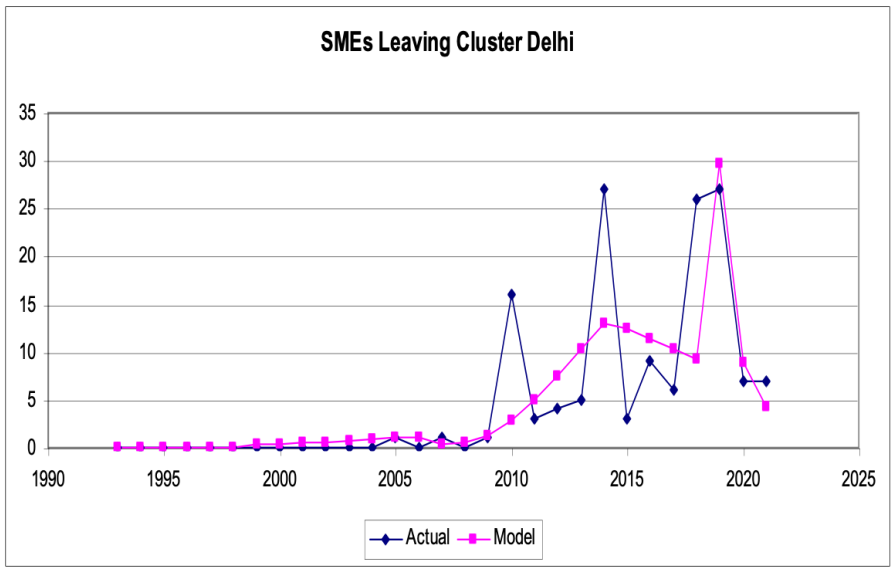

Figure 3f. SME Leaving the Cluster: Delhi Region

Figure 3. Calibration of the SMS in the cluster – Delhi and Maharashtra regions

This leads to a further examination of the possibilities of new additions after 2021 to reverse the downward trend in the number of SMEs in the cluster. **Table 3** shows the initial values obtained from the calibration of the Delhi and Maharashtra regions. It reveals the number of SMEs within the cluster and the infrastructure, financial, and human resources.

Table 3. Initial Values from the Calibration of the Two Regions

Initial Values	Units	Maharashtra	Delhi
SME in Cluster	Businesses	2	1
Infrastructure	Buildings	1	8
Financial Resources	USD	10,000,000	10,000,000
Human Resource	People	1039	498
Infrastructure Additions	Buildings/Year	12.91	0.01
Financial Resources Additions	USD/Year	1,000,052	1,000,121
Human Resources Additions	People/Year	121	172

Table 4 depicts the constants used in the model for both regions in the calibration. As a result, the annual additions after 2006 were identical for both regions, and the annual additions after 2018 were identical for both regions.

Table 4. The Constants for the Model Found in the Calibration

Constants	Units	Values
Infrastructure Consumption Rate	Buildings/Year	0.003
Financial Resources Consumption Rate	USD/Year	10,533
Human Resources Consumption Rate	People/Year	24
Infrastructure Additions after 2006	Buildings/Year	0
Infrastructure Additions after 2018	Buildings/Year	1.64
Financial Additions after 2006	USD/Year	100,063
Financial Additions after 2018	USD/Year	99,860
Human Resources Additions after 2006	People/Year	1,685
Human Resources Additions after 2018	People/Year	0
Normal Joining Rate	Businesses/Business/Year	0.50
Joining Rate Multiplier for Infrastructure	Dimensionless	0.716
Joining Rate Multiplier for Financial Resources	Dimensionless	0.851
Joining Rate Multiplier for Human Resources	Dimensionless	0.510
Normal SME Life Span	Years	12.61
Life Span Multiplier for Infrastructure	Dimensionless	1.170
Life Span Multiplier for Financial Resources	Dimensionless	1.851
Life Span Multiplier for Human Resources	Dimensionless	1.240

4.3. *Resource Additions for reversing the Declines Beyond 2021*

Optimisations were executed to reverse the declining number of SMEs in the clusters, particularly in choosing optimal additions after 2021. Given a budget of 20 million USD per year, it is discovered that the national government should attempt to add 0.43 buildings, 2,910,000 USD in financial resources, and 333 skilled persons to each region per year. This assumes that building infrastructure costs 1,000,000 USD per unit and the cost of developing human resources is 50,000

USD per person (See **Table 5).**

Table 5. Optimal Resource Additions to Reverse the Downward Trend in the Number of SMEs in the Clusters Beyond 2021

Additions after 2021	Units	Cost	Values
Infrastructure	Buildings/Year	1,000,000	0.43
Financial Resources	USD/Year	1	2,910,000
Human Resources	People/Year	50,000	333

Figures 4a and 4b show that this level of annual additions will turn around the downward SME trends in Maharashtra and Delhi regions. Although the additions suggested for reversing the downward trend are identical for both regions, their impacts are not. **Figures 4c through 4e** show the impacts of infrastructure, financial, and human resources on the SME joining rate for the two regions studied. The additional resources have a similar impact on the lifespan of the SME. **Figures 4c &4d** indicate that the investment in additions to infrastructure and financial resources is projected to reach a point of diminishing returns by 2030. On the other hand, **Figure 4e** indicates that the current level of investment in additional human resources is insufficient and it becomes a limiting factor in the growth rate of the cluster.

Compared to other studies, the criteria and drivers that influence the growth of businesses within clusters have been investigated based on existing literature. These drivers derive from and lend credence to studies such as **Nursyamsi and Moeis (2018)** and **Dragičević and Obadić (2014).** Furthermore, this study aligns with that of Rašić Bakarić**(2017),** who identified that the financial performance of clustered SMEs is boosted due to access to resources. The potential to increase enterprise competitiveness and productivity, contribute to innovation, create jobs, and enhance new business formation. The observed patterns for the Maharashtra region mirror the overshoot-and-collapse behaviour of systems, as depicted by **Ford (2019).**

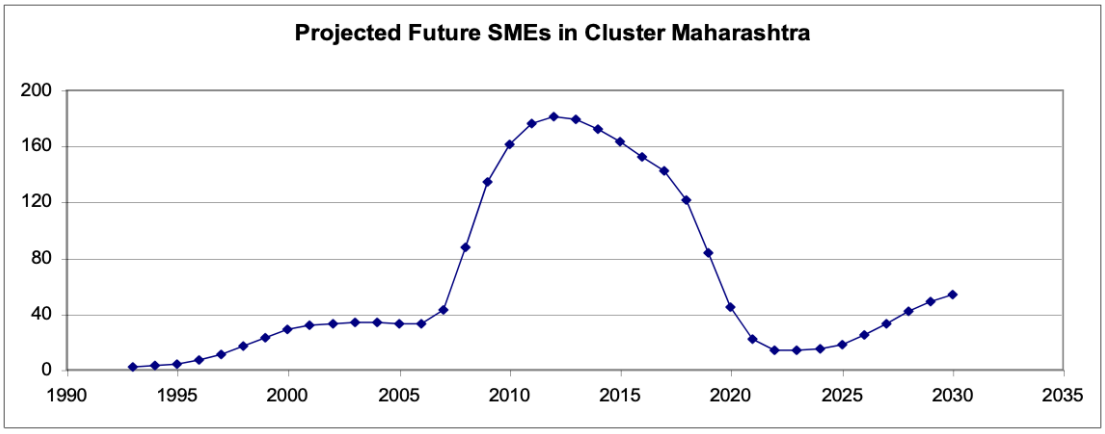

Figure 4a. Projected Turnaround for Maharashtra Region after 2021

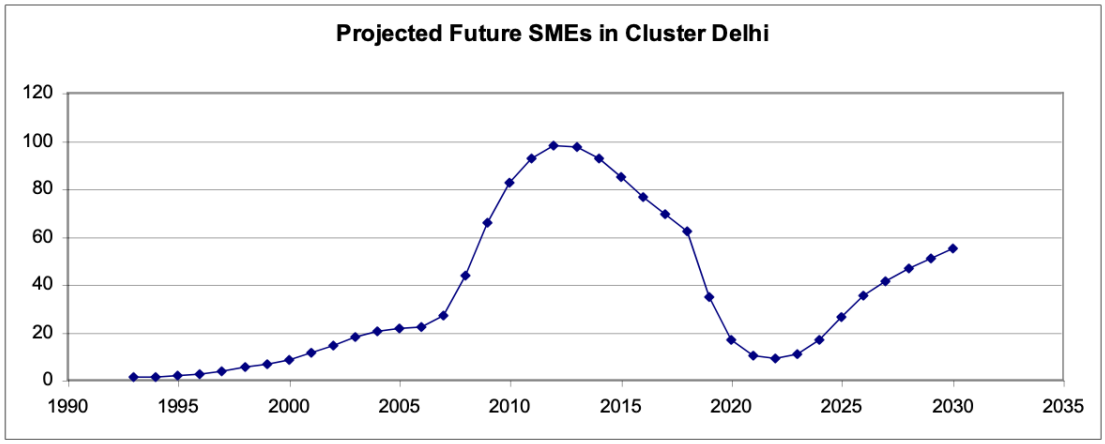

Figure 4b. Projected Turnaround for Delhi Region after 2021

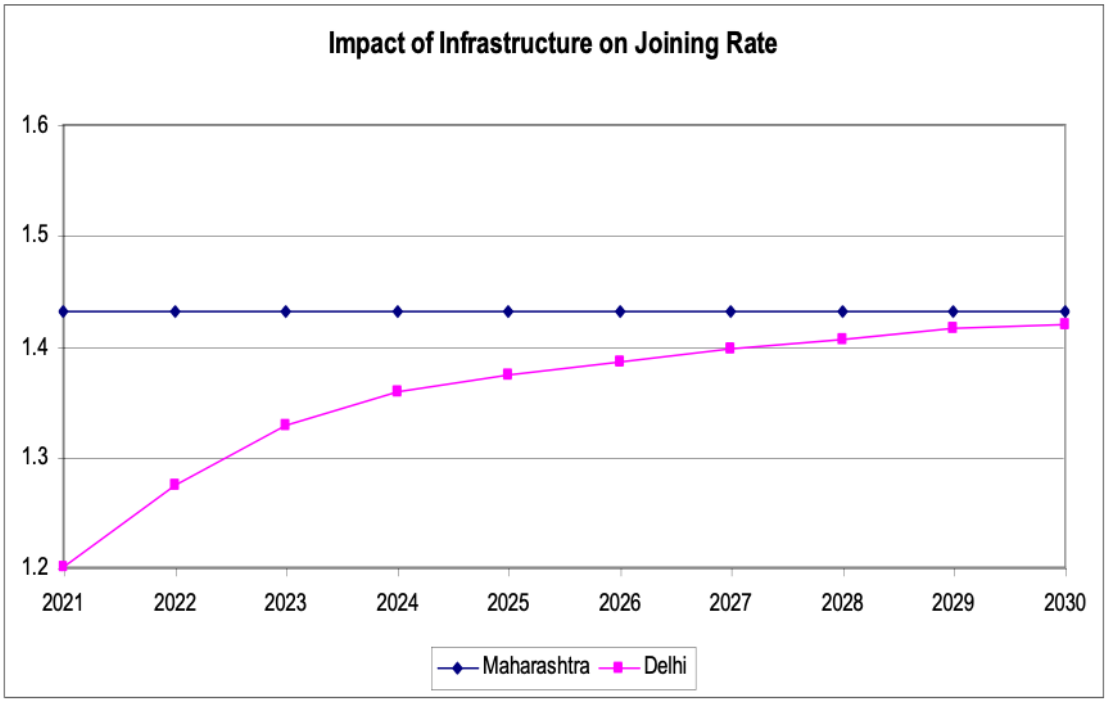

Figure 4c. Impact of Infrastructure on SME Joining Rate

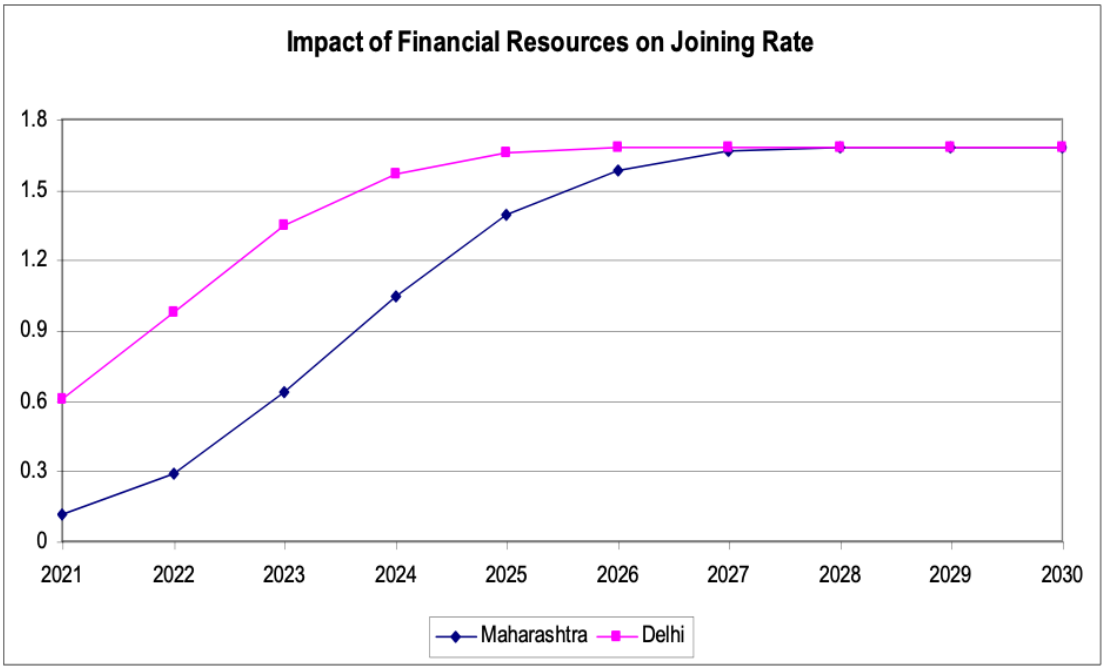

Figure 4d. Impact of Financial Resources on SME Joining Rate

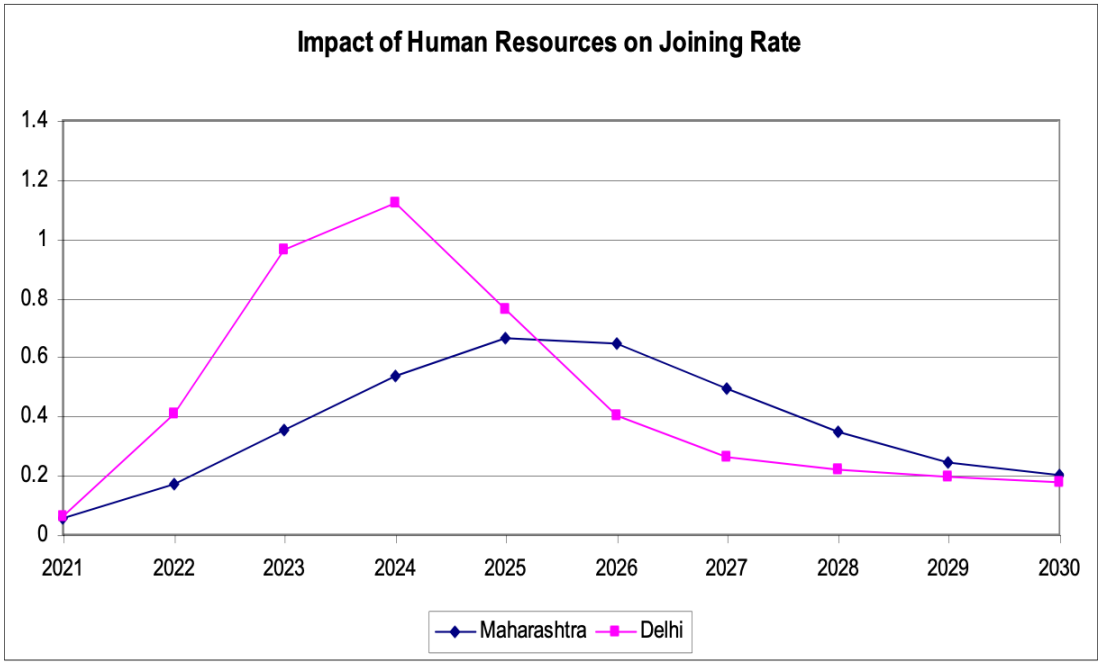

Figure 4e. Impact of Human Resources on SME Joining Rate

Figure 4. Project Turnaround and Impact on SME (Infrastructure, Financial Resources and Human Resources)

4.4. *Practical and Social Implications*

This study shows the problems associated with sustaining a growing SME cluster with fixed resources. In the early stages of the cluster's life, the extra capacity will draw new SMEs into the cluster. However, the delays in the system will lead to

an overshoot and collapse behaviour once the number of SMEs exceeds the carrying capacity of the fixed resources. Hence, the study provides a validated SD model of a location-based SME cluster, while the existing SD models on SMEs broadly lack proper validation. Also, this research fills a crucial substantive and methodological gap in the study of SMEs. Moreover, the study recommends the optimal resource additions needed to reverse the declining number of SMEs in the clusters.

The SD model will interest policymakers in many countries because SMEs contribute greatly to developing economies. The model can determine an optimal annual amount of financial, infrastructural, and human resources necessary to grow and sustain SME clusters in India and the developing world.

4.5. *Research Limitations*

Some limitations identified in this study relate to the practical conditions. First, 'other-controllable' influencers of the location-based SME could be considered in the model. Secondly, the exclusion of the lifecycle of the SME can be considered another limitation. Thirdly, the impact of growth in the variable 'additions to resources' per year is not considered. Fourthly, the nature, in terms of the 'amount of resource additions' per year, and the impact of its growth could be investigated in future work.

5. Conclusions

This study has significantly contributed to the body of knowledge through the following:

As the first step, this study successfully identified and categorised the drivers found in the literature to influence the growth of business clusters. Subsequently, the variables influencing the growth/decline of SME clusters (infrastructure, financial and human resources), have been investigated. This was done with the aid of a calibrated and validated SD model. The validated SD model was also employed to examine multiple scenarios among the clustered SMEs.

Also, this study has examined the interactions among the SME clusters within the Maharashtra and Delhi regions in India, a large and evolving economy, while showing the number of SMEs joining and leaving. The optimisation and exploration of policy options were conducted to improve SME growth within clusters.

Additionally, the multidimensional effects of changes in these resources on SME clusters are quantified. The study shows that the introduction of the 2006 MSMED policy led to a rapid increase in the number of SMEs in the clusters in Maharashtra and Delhi. However, this growth was not sustainable, and the number of SMEs in these clusters began to decline around 2014. The amended 2018 MSMED policy did not slow the decline. We believe this decline was created by the exhaustion of the financial, infrastructural, and human resources allocated to SME clusters. The study concludes that resources must be an optimal addition if we want to reverse this decline each year.

Moreover, the calibrated model has shown that there have been cycles of growth and decline in the number of SMEs in the clusters in Maharastra and Delhi created by the exhaustion of a fixed amount of additions to the sustaining resources

per year. The logical conclusion to this observation is that as the cluster grows, the additions in financial, infrastructural and human resources per year need to grow in parallel. Once the SME cluster grows to the desired size, the number of additions of resources per year might no longer need to grow and may reach an equilibrium. This should result in a sustainable SME cluster of the desired size. Also, additional investment in infrastructure and financial resources is projected to reach a point of diminishing returns by 2030. Also, the SD model could inform practical policy approaches for the success of the SME clusters in India and the developing world.

Statements and Declarations

Funding: NIL.

Authors' Contributions: There is no potential conflict of interest.

Software Used: https://vensim.com/

Calibrated System Dynamics Model: https://github.com/ivanwtaylor/SME-Clusters

Availability of data and material: Significant parts of the model were validated using the data accessed from the Centre for Monitoring Indian Economy (CMIE), Govt of India, website. All sources of data are listed under the References section.

References

- Anufriev, D., & Holodov, A. (2018). Description of approaches to the study of decentralized complex systems in the management of the regional construction cluster. In MATEC Web of Conferences (Vol. 251, p. 05008). EDP Sciences.
- Bakarić, I. R. (2017). The impact of cluster networking on business performance of Croatian wood cluster members. Croatian Review of Economic, Business and Social Statistics (CREBSS), 3(2) 39-61.
- Bhamra, M. & Kishore, K. (2022). Strategies for Cluster Branding in MSMEs Clusters: A Grounded Theory Approach. Global Business Review 1–19. Available: in.sagepub.com/journals-permissions-india DOI: 10.1177/09721509221124166 journals.sagepub.com/home/gbr
- Bylok, F., Pabian, A. & Kuceba, R. (2016). Management of a cluster as a network for cooperation between SMEs in Poland. Small Enterprise Research, 23(2), 172–181.
- Cavén, H. (2011). What is the role of a cluster in the business cooperation development? A Bachelor's thesis, International Business, HAMK University of Applied Sciences.
- Čolović, Z. K., Beran, I. M. & Raguž, I. V. (2016). The impact of clustering on the business performance of Croatian SMEs, Economic Research-Ekonomska Istraživanja, 29:1, 904-913.
- Cosenz, F., & Bivona, E. (2021). Fostering growth patterns of SMEs through business model innovation. A tailored dynamic business modelling approach. Journal of Business Research, 130, 658-669.
- Centre for Monitoring Indian Economy Pvt. Ltd. (CIME, 2021) Available: Centre for Monitoring Indian Economy Pvt. Ltd. OR https://www.cmie.com/ Accessed January 6, 2022.

- Darussalam Enterprise (DARe) (2017). Recognizing the contribution of businesses to the community and economy and the need to support MSMEs to enable their growth. Association of Southeast Asian Nations. www.asean.org
- Delgado, M., Porter, M. E., & Stern, S. (2010). Clusters and entrepreneurship. Journal of Economic Geography, 10(4), 495-518.
- Delgado, M., Porter, M. E., & Stern, S. (2014). Clusters, convergence and economic performance. Research Policy, 43, 1785-1799.
- Das, S.S., and Das, A. (2014). India shining? A two-wave study of business constraints upon micro and small manufacturing firms in India, International Small Business Journal, 32(2), 180-203.
- Dangelico, R. M., Garavelli, A. C., & Petruzzelli, A. M. (2010). A system dynamics model to analyze technology districts' evolution in a knowledge-based perspective. Technovation, 30(2), 142-153.
- Ekeh, L. U. (2017). Industrial Clusters can Boost State Government Economies in Nigeria. Sundiata Post, Abuja, Nigeria.
- Europe INNOVA (2008). Case Studies of Clustering Efforts in Europe: Analysis of their Potential for Promoting Innovation and Competitiveness. European Presidential Conference on Innovation and Clusters, Stockholm.
- Feldman, M., Francis, J., & Bercovitz, J. (2005). Creating a cluster while building a firm: Entrepreneurs and the formation of industrial clusters. Regional studies, 39(1), 129-141.
- Fonseca, J. P., Ferreira, F. A., Pereira, L. F., Govindan, K., & Meidutė-Kavaliauskienė, I. (2020). Analyzing determinants of environmental conduct in small and medium-sized enterprises: A sociotechnical approach, Journal of Cleaner Production, 256, 120380.
- Fornahl, D., Hassink, R., & Menzel, M. P., (2015). Broadening Our Knowledge on Cluster Evolution. European Planning Studies, 23:10, 1921-1931.
- Government of India. (2018). What are micro, small and medium enterprises? Retrievedhttps://msme.gov.in/know-about-msme
- Haghighi-Rad, F., Ghadimi, R., & Goldoust, F. (2019). Evaluation of trade and production policy in Iranian SME (a system dynamics model). Journal of Industrial Engineering International, 15(1), 69-86.
- Hristoski, I. S., & Kostoska, O. B. (2018). System dynamics approach for the economic impacts of ICTs: evidence from Macedonia. Information Development, 34(4), 364-381.
- ICIC (2019). Economic Development, Cluster growth and Evaluation. Available online at www.icic.org/research/economic-development/ Accessed 23/07/2021.
- JPMorgan Chase & Co. (2014). The Missing Link: Clusters, Small Business Growth and Vibrant Urban Economies an Analysis of Small Business Development Strategies in the Nation's Ten Largest Cities. JPMorgan Chase & Co. // ICIC. pp 1-12.
- Katti V. P. & Mujumdar, P. (2022). Impact of Government Policy Measures on Small and Medium Enterprises of Automotive Component Industry Working in Pune Auto Cluster. SEDME (Small Enterprises Development, Management & Extension Journal) 49(2) 192–201, 2022. Available: in.sagepub.com/journals-permissions-india DOI: 10.1177/09708464221103322
- Kotturu, C. M. V., & Mahanty, B. (2017). Determinants of SME integration into global value chains: Evidence from

Indian automotive component manufacturing industry. Journal of Advances in Management Research.

- Kurniasih J., Kurniasih, Abas, Z. A., Asmai, S.A., & Wibowo, A. B. (2023). System Dynamics Approach in Supporting the Achievement of the Sustainable Development on MSMEs: A Collection of Case Studies. (IJACSA) International Journal of Advanced Computer Science and Applications. Vol. 14, No. 6, pp 990-998.
- Li, F. J., Dong, S. C., & Li, F. (2012). A system dynamics model for analyzing the eco-agriculture system with policy recommendations. Ecological Modelling, 227, 34-45.
- Lin, C. H., Tung, C. M., & Huang, C. T. (2006). Elucidating the industrial cluster effect from a system dynamics perspective. Technovation, 26(4), 473-482.
- Madaleno, M. & Nathan, M. & Overman, H. & Waights, S. (2018). Incubators, accelerators and regional economic development, CEP Discussion Papers dp1575, Centre for Economic Performance, LSE.
- Marafioti, E., Mollona, E., & Perretti, F. (2021). Long-term sustainability of clusters: A dynamic theory of de-clusterization. Journal of Simulation, 15(1-2), 159-176.
- Menzel, M.-P. & Fornahl, D. (2010). Cluster life cycles—Dimensions and rationales of cluster evolution, Industrial and Corporate Change, 19(1), pp. 205–238.
- MSME (2019). Annual Report of MSMEs, available athttps://msme.gov.in/documents/reports-and-publications [accessed 16-May, 2021]
- MSMED Act (2006). MSME Annual Report, available athttp://sisihyd.gov.in/MSME/SalientFeaturesMSMEDAct.pdf (accessed 2-May, 2021).
- MSME SAMADHAAN (2006). The MSMED Act, 2006, Retrieved: samadhaan.msme.gov.in [accessed 12-May, 2021]
- Make in India (2021). Doing Business Retrievedhttps://www.makeinindia.com/eodb
- Marques, F. C., Ferreira, F. A., Zopounidis, C., & Banaitis, A. (2020). A system dynamics-based approach to determinants of family business growth. Annals of Operations Research, 1-21.
- Martínez-Marín, S., Puello-Pereira, N., & Ovallos-Gazabon, D. (2020). Cluster competitiveness modeling: An approach with systems dynamics. Social Sciences, 9(2), 12.
- Navickas, V. & Malakauskaitė, A. (2009). The Impact of Clusterization on the Development of Small and Medium-Sized Enterprise (SME) Sector. Journal of Business Economics and Management 10(3): 255–259.
- Njøs, R. & Jakobsen, S. –E. (2016). Cluster policy and regional development: scale, scope and renewal. Regional Studies, Regional Science, 3:1, 146-169.
- Nursyamsi, A., & Moeis, A. O. (2018, March). Effect of Policy Analysis on Indonesia's Maritime Cluster Development Using System Dynamics Modeling. In IOP Conference Series: Earth and Environmental Science (Vol. 127, No. 1, p. 012019). IOP Publishing.
- OECD (2005). Business Clusters: Promoting Enterprise in Central and Eastern Europe, Local Economic and Employment Development (LEED), OECD Publishing, Paris.
- Porter, M. E. (1998). Clusters and the new economics of competition. Harvard Business Review 76, 77–90.
- Richardson, G., (2011). Reflections on the foundations of system dynamics, System Dynamics Review, 27(3), pp. 219-243.
- Rocha, H., Kunc, M., & Audretsch, D. B. (2020). Clusters, economic performance, and social cohesion: a system

dynamics approach. Regional Studies, 54(8), 1098-1111.

- Ford, D. N. (2019). A system dynamics glossary. System dynamics review, 35(4), 369-379.
- Skalholt, A. & Thune, T. (2014). Coping with economic crises—The role of clusters. European Planning Studies, 22(10), pp. 1993–2010.
- SMEDAN/NBS (2013). SMEDAN and National Bureau of Statistics Collaborative Survey: Selected Findings.
- Sterman, J.D. (2000). Business Dynamics: Systems Thinking and Modelling for a Complex World. Boston: Irwin/McGraw-Hill.
- Shakib, M. D. (2020). Using system dynamics to evaluate policies for industrial clusters development. Computers & Industrial Engineering, 147, 106637.
- Saha, N., Jirčíková, E., & Bialic-Davendra, M. L. (2011). The power of clustering and HRM as a source of competitive advantage: Evidence from clusters from Poland, Slovakia, the Czech Republic, India and developed countries. Journal of Competitiveness.
- Suryani, E., Hendrawan, R. A., Rahmawati, U. E., Cahyandini, G. A., Mahardhika, M. A. S., & Riski, R. (2020, October). Model Scenario to Increase Market Share and Profitability of MSMEs through Business Process Digitalization. In 2020 6th Information Technology International Seminar (ITIS) (pp. 7-12). IEEE.
- Schwab, L., Gold, S., & Reiner, G. (2019). Exploring financial sustainability of SMEs during periods of production growth: A simulation study. International Journal of Production Economics, 212, 8-18.
- Teekasap, P. (2009). Cluster Formation and Government Policy: System Dynamics Approach. In: Proceedings of the 27th International System Dynamics Conference, Albuquerque, New Mexico, USA.
- Temouri, Y. (2012). The Cluster Scoreboard: Measuring the Performance of Local Business Clusters in the Knowledge Economy. LEED Working Papers 2012/13, OECD Publishing, Paris.
- Ter Wal, A. L. J. & Boschma, R. A. (2011). Co-evolution of firms, industries and networks in space. Regional Studies, 45(7), pp. 919–933.
- Tsakalerou, M. (2015). Cluster Management: From Economic Agglomeration to Leveraging Innovation. European Scientific Journal, 11(4), pp. 15-24.
- UNIDO. Industrial Development Report 2009. Development 2009, 12, 99.
- Uriona, M., & Grobbelaar, S. S. (2019). Innovation system policy analysis through system dynamics modelling: A systematic review. Science and Public Policy, 46(1), 28-44.
- Venugopal, P., Malhotra, R., & Annamalai, B. (2018). The determinants for sustainability in a low-technology SME textile cluster in an emerging economy. International Journal of Business Innovation and Research, 15(3), 340-356.
- Vojtko, V., Rolínek, L., & Plevný, M. (2019). System dynamics model of crises in small and medium enterprises. Economic research-Ekonomska istraživanja, 32(1), 168-186.
- Yan, B., & Liu, L. (2018). A new transhipment policy in cluster supply chains based on system dynamics. RAIRO-Operations Research, 52(1), 1-15.
- Zheng, C. H., & Huang, H. L. (2018). Analysis of technology diffusion in agricultural industry cluster based on system dynamics and simulation model. Journal of Discrete Mathematical Sciences and Cryptography, 21(6), 1211-1214.
- Zhang, Y. (2019). Case Analysis of the Boost Effect of Port Trade on Regional Transoceanic Economy Based on

Industrial Cluster Effect. Journal of Coastal Research, 94(SI), 768-772.

- Zhou, X., Ma, J., Fu, D., & Yan, H. (2019). Research on the interaction between logistics industrial clusters and urbanization based on system dynamics and cloud model. International Journal of Internet Manufacturing and Services, 6(1), 97-121.