Minnesota Journal of Business Law and Entrepreneurship

Volume 2026, No. 2

ISSN: 1540-3270

Examining the Role of Systems Thinking in Managing Complex Adaptive Systems: An Empirical Investigation of Indian Startups

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Abstract

The widespread ambiguity, interrelatedness and swift technological developments within a contemporary organizational landscape have amplified the significance of systems thinking in an administrative decision-making. Indian startups function within an extremely dynamical and competitive network and mostly behave as Complex Adaptive Systems (CAS), wherein several driving forces constantly communicate, amend and develop. This research investigates the role of systems thinking in handling intricacy within Indian startups. The research aims at comprehending interrelatedness, identifying several stakeholder mindsets, instituting acceptable limitations and reacting in effect to the dynamic market situations. It also studies the importance of adaptive, emergent and cooperative conducts in improvising business flexibility, innovativeness, and ecological balance. By implementing systems thinking theories to startup ecology, the research points out the significance of a complete decision-making, collaboration and elasticity in ambiguous business landscape. The results indicate that startups implementing systems thinking methods are better trained to handle uncertainty, boost resources, foster innovation and attain sustainable growth in an extremely complex and cut-throat market.

Keywords: Systems Thinking, Complex Adaptive Systems, Indian Startups, decision-making

Introduction

The modern business environment highly moulded with vagueness, swift technological developments, interrelated markets, and developing customer expectations. Conventional linear management practices are mostly incapable to confront the dynamic and unstable behaviour of contemporary firms. With respect to this, systems thinking has surfaced as a significant method which supports firms to comprehend networking, review strategies, adaptability, and a huge influence of organizational decisions. System thinking allows businesses to examine issues comprehensively instead of aiming at remote factors, thus improvising strategic judgemental skills and business

flexibility (Janssen, 2025). Past research also recommend that AI-based knowledge management systems notably improvise business judgements, collaboration and ecological growth in a dynamic organization landscape (Mittal et al., 2023).

Indian startups portray the fastest-growing entrepreneurial ecosystems widely and function in a extremely cutting edge and unpredictable environments. These startup constantly communicate with investors, customers, technologies, competitors and administrative system making it identical to Complex Adaptive Systems (CAS). These systems are defined by interrelated factors, adaptive training, self-organization and upfront behaviour. Because of swift market transformation and restricted resources, startups need elastic and adaptive managment methods which assist innovation and ecological balance.

Systems thinking offers startups with an outline to comprehend intricacy, recognize interrelatedness and react productively to sustainable changes. It also augments collaboration, distributed decision-making and adaptive learning, that are fundamental for structural endurance in unpredictable situations. Studies further focuses which experiential knowledge and adaptive skill-enhancement methods foster organizational awareness and innovative skills in swiftly transforming environment (Gupta et al., 2024). Past research has emphasized that businesses working withing intricate adaptive environments profit notably from system-oriented policies to innovation, enterprise risk management, and resilience building (Sheth & Sinfield, 2024). Moreover, innovative landscape and collaborative ecosystem have become extremely imperative for startups to endure cutthroat and long-tern development (Brem et al., 2024).

Inspite of the rising significance of systems thinking in organizational management, inadequate study has particularly scrutinized its role in handling intricate adaptive systems within Indian startups. Hence, this study focuses in examining how systems thinking impacts complexity management, adaptability and sustainable development in Indian startup networks.

Literature Review

Systems Thinking

A system is group of parts that interact, interrelate, or interdependent and form a complex and combined whole that has specific purpose or goal (Meadows, 2008). On the other hand, Systems Thinking is a way an individual sees and talk about the reality that help him or her to understand it better (Senge, 2006). This enables to work with systems in a better way to influence the quality of life. In this context, systems thinking can be seen as a viewpoint that has a unique vocabulary which describes the systemic behaviour and can be thought of as a "language" as well (Capra & Luisi, 2014). Systems thinking is a kind of set of tools as it offers different type of techniques and devices that helps in visual capturing and communication about systems (Arnold & Wade, 2015).

In systems thinking and practice, the processes of analysis, decision-making and management are aligned with complicated and adaptive systems behaviour (Checkland, 1999). As individuals, we all know that our day-to-day lives are "complex, highly interconnected and often rather messy" and it is accepted that it evolves in even more unpredictable ways (Ramalingam, 2013). And since these evolutions are not in our control, we keep on trying to cope, prosper, learn and adapt. On the other hand, in our "professions, organisations, and the domains of policy and governance", we generally imagine that the complexity and uncertainty can be ignored. It is frequently seen that "Disciplinary, oversimplified, linear and hierarchical ways of thinking and making decisions" dominate (Sterman, 2000).

Systems thinking and practice means:

- System thinking and practice means to look at the situation as a whole system and understand the key relation that shapes how a system behaves.

- Accept the "uncertainty and complexity of systems", and work in adaptive, flexible and learning-oriented ways.
- Recognise that there is legally different viewpoint of different people and group and one need to see "the system" in different manner.
- See that the flexibility and resilience of the stem is related to "communication networks, diversity, decentralised decision-making and idleness."
- To work in "interdisciplinary and cross-sectoral" ways.

Possibly, this all sounds like common sense, but it is amazing to know that how difficult it is to apply this kind of thinking given organisational restrictions, time burdens, and the limitations of our own and professional training of others as well.

The Nature of Complex Adaptive Systems

Systems thinking has the ability to make difference between "hard systems and complex adaptive systems" (Holland, 1992). Complex adaptive system (CAS) has different components called agents that are interdependent, act as a whole, able to learn from the last experiences and adapt to environmental changes (Gell-Mann, 1994). CAS is identified by their non-linear behaviour, where significant and unpredictable results can be seen even on small changes (Mitchell, 2009). Emerging properties is the nature of Complex Adaptive Systems and the collective behaviour of the system is more complicated as compared to sum of its individual parts (Holland, 1995). The primary nature of CAS is "self-organization, adaptation, and the continuous evolution of the system" where the agents keep on learning and modifying their actions (Kauffman, 1993). Examples include "ecosystems, human societies, financial markets, global economy, stock markets, emerging cities, online social networks, internet, neural networks, swarms, and rainforests" (Mitchell, 2009).

Adaptive Behaviour: In adaptive behaviour, CAS shares a common ground with traditional perspective of market processes. A similar view of the outcomes of supply interactions, demand, and other self-correcting mechanisms is provided by economics and complexity. The difference lies in the valuations and calculations conducted to describe the same phenomenon. Generally, the adaptive behaviour is seen in the stock market where the investors react on the information which is collected and analyzed by them. Recent studies also point out that digital and social media data notably impacts investor perspective and adaptive judgements within banking organizations (Mittal et al., 2025).

Complex Adaptive Systems show adaptive behaviour whose primary nature is dynamic interactions among its agents. These agents adapt and evolve on the basis of feedback they get from their environment (Holland, 2006). Systems like "ecosystems, economies, and social structures" adjust themselves with the help of decentralized decision-making that enables them to respond to changes, learn, and organize themselves without any central control (Axelrod & Cohen, 2000). The system shows the adaptive nature due to the developing nature of the individual components that interact at local level and leads to complex, unpredictable global patterns that allow the system to sustain and evolve over time (Mitchell, 2009).

Emergent Behaviour: The emergent behaviour in Complex Adaptive Systems (CAS) mentions the patterns or properties that comes from the collective interactions of individual agents within the system (Goldstein, 1999). It is not possible to predict these interactions by analyzing the agents in isolation. The emergent behaviour is the result of local interactions and adaptations and there is no centralized control in this process (Johnson, 2001).The whole system shows the features that are greater than the sum of its parts and this leads to complicated results that can be stable and evolve over the time (Holland, 1998). **Example:** "formation of social networks, the self-regulating nature of ecosystems, and the adaptive trends seen in economies." In general, the interacting agents of a typical CAS shows the features of "emergent behaviour" where no visible leader is found and there is a collective force that drives the system. Regulators, network providers, technology suppliers, and consumers are the main four interacting agents that drives the telecommunication industry where they act, react, and evolve as a whole unit.

Cooperative Behaviour: In a complex adaptive system, cooperative behaviour helps the organization to change, evolve, and grow rapidly (Axelrod, 1984). Compatible network platforms and common industry standards are developed with the help of cooperation among technology firms. Other than price and quantity, there are other parameters that are covered by CAS in the world where there are rapid changes in innovation, product specifications, and quality. In Complex Adaptive Systems, cooperative behaviour occurs on direct or indirect interaction of individual agents. They work together to get the results that benefit the system as a whole (Nowak, 2006). Cooperation helps a complex adaptive system to solve complicated problems, optimize the use of different resources, and efficiently adapt to environmental changes. **Example**: "synchronized behaviour of bird flocks, the mutualistic relationships in ecosystems, and collaborative strategies within human social and economic systems." Frequent improvement is observed in overall stability and ability of the system with the help of these cooperations that also helps the system to respond to challenges in more effective way.

Three key aspects of systems thinking

Relationship, perspectives, and boundaries are the three key elements down which systems thinking can be boiled at its core (Midgley, 2000). The primary focus of systems thinking is to give importance to the process of identification and analysis of connections and interactions among different components within a system (Senge, 2006). This helps to know that how the whole system gets affected when some changes take place in any one part of the system which in turn promotes to better problem-solving and holistic solutions. Recognising different perspectives acknowledges that various stakeholders or parts of a system may have different views and insights (Checkland, 1999). When these different perspectives are considered, it improves our process of understanding complex issues and increases the chances of collaborative approaches. When the boundaries are clearly set, it becomes easier to understand what is included within the system under analysis. This approach helps to focus efforts, avoid scope creep, and ensure that solutions are targeted and effective (Midgley, 2000). When all these features work together, they create a comprehensive view that leads to effective decision-making and sustainable results. Each is detailed below, accompanied by key questions to consider when analyzing a situation from a systemic perspective:

Understand Interrelationships: Understanding inter relationships is a key feature of systems thinking that recognize different components within a system and how they are connected and influence each other (Sterman, 2000). Linear thinking assesses cause and effect as straight forward, but on the other hand, systems thinking acknowledges the elements that interact in dynamic and active ways. The system behaviour is directly affected by these interactions as they create the feedback loops and non-linear responses. When we focus on interrelationships, it helps us to see the bigger picture, identify leverage points, and predict the potential impact of changes within the system in much better ways. This perspective is essential to address complex problems that also help to uncover root causes and inter connected consequences. The ability to think about a system as a whole in spite of considering the parts as individual is system thinking. This observes the world as a multifaceted system and help an individual to understand its inter-connections and inter-relations. System is all about the inter relation amid its components or actors that shows the way how the overall system is shaped by these inter relations, and at the same time, how the inter relations are also shared by the overall system. The systems thinking mainly focus to understand the system as a whole in spite of breaking it into single parts. In systems thinking, one may know how different parts interact with each other and contribute to behaviour and results of the whole system. It also helps us to understand how to change systems more efficiently, and to act more in tune with the natural processes of the natural and economic world.

Recognise Different Perspectives: System thinking pave the ways to think and understand an issue and its solutions by the perspectives of a whole system (Senge, 2006). It is also the fact that no blueprints are available for being a system thinker, it is all the mindset with which an individual works rather than against the way multi-layered adaptive or human systems work. In system thinking, one takes different viewpoints, surface different world views and ask the question about the whole system. Different perspectives of the system are essential for the staff to stay connected to their line of work along with others to get a deep understanding of the key inter relations. It is important to bring multiple perspectives on the table to tackle complicated issues (Checkland, 1999). Systems thinking help different components to understand how their long-term interests help them to make good

interconnection with others that leads to open up ways for better constructive dialogues. The key aim of system thinking is to open discussion between people having different opinion and understandings. Different perspectives and experience on the same table help to evaluate how the current knowledge and technique can be used to get the solution of present needs. When we try to develop rapid responses to a critical situation, it is very tough for the systems principle to bring different perspectives on the same table.

Establish boundaries: To draw a boundary between the components that needs to be inside and outside of the system is the common feature of the systems thinking (Midgley, 2000). Difference making process is same as the analysis of the boundary where both processes draw line between what is in and what is out of a particular system. The analysis and the evaluation of the boundary also indicate how one must be clear of these boundary decisions. On the other hand, difference making process is an automatic process that keeps on going all the time. Drawing boundaries and making differences or divisions is a characteristic part of our thought process. While being unsympathetically reflective about these boundaries is secondary, the act of clearly making differences and accepting various viewpoints naturally inspires critical reflection. This process highlights how different boundaries are apparent differently depending on the perspective, which lies at the heart of systems thinking (Ulrich, 1983). All the systems thinking is a "closed" systems thinking which means that they always had some kind of boundary and this boundary is mostly random or based on some specific needs of the systems thinker. **Example**: In the space, the boundary of the solar system is thought of as an imaginary container. Similarly, in the circulatory system, the conceptual boundary says that all the tissues in the body takes part in the process of circulation. But, when we think of the circulatory system, we ignore all the other vital characteristics and include only the tissues that take part in the blood flow.

Objective

1. To examine the role of Systems Thinking in Managing Complex Adaptive Systems in Indian Start-ups.
2. To know the impact of Systems Thinking on Managing Complex Adaptive Systems.

Methodology

259 participants were surveyed from different people at different managerial levels. The method of sampling was "Random sampling" for collection of data and examination was done by "Explanatory Factor Analysis and multiple regression" for results.

Findings

Table 1 demonstrates demographic details, it shows that 51.35% are Male, 48.65% are female. Looking at the age, 29.73% are between 35 to 40 years of age, 38.22% are between 40 to 45 years of age, and 32.05% are above 45 years of age. With regards to the Managerial level, participants who are founder are 37.27%, 26.94% are Co-founders and 35.79% are Chief Executive Officer (CEO)

Table. 1 Respondent's Details

Variables	Participants	Percentage
Gender		
Male	133	51.35%
Female	126	48.65%
Total	**259**	**100**

Ages in years		
35 to 40	77	29.73%
40 to 45	99	38.22%
Above 45	83	32.05%
Total	**259**	**100**
Managerial Levels		
Founders	101	37.27%
Co-founders	73	26.94%
Chief Executive Officer (CEO)	97	35.79%
Total	**259**	**100**

"Factor Analysis"

"KMO and Bartlett's Test"

Table. 2 "Kaiser-Meyer-Olkin Measure of Sampling Adequacy"

"Kaiser-Meyer-Olkin Measure of Sampling Adequacy"		.772
"Bartlett's Test of Sphericity"	"Approx. Chi-Square"	4415.585
	df	91
	Significance	.000

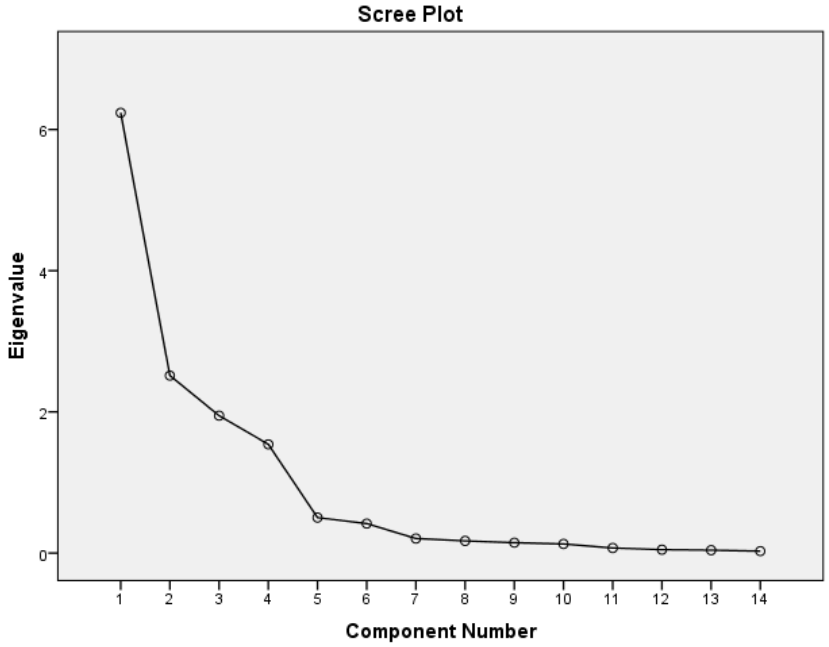
"KMO and Bartlett's Test", value of KMO is .772 (Table 2).

Table 3 "Total Variance Explained"

"Component"	"Initial Eigenvalues"			"Rotation Sums of Squared Loadings"		
	"Total"	"% Of Variance"	"Cumulative %"	"Total"	"% Of Variance"	"Cumulative %"
1.	6.237	44.550	44.550	3.810	27.217	27.217
2.	2.514	17.958	62.508	3.619	25.851	53.068
3.	1.946	13.901	76.409	2.515	17.966	71.034
4.	1.541	11.004	87.413	2.293	16.379	87.413
5.	.503	3.591	91.003			
6.	.418	2.984	93.988			
7.	.206	1.469	95.457			

8.	.172	1.230	96.686			
9.	.146	1.046	97.733			
10.	.130	.925	98.658			
11.	.072	.514	99.172			
12.	.048	.344	99.516			
13.	.040	.289	99.805			
14.	.027	.195	100.000			

The four factors contribute towards explaining total 87.413% of variance. Variance explained by Adaptability and Flexibility is 27.217%, Complexity Management is 25.851%, Strategic Decision-Making is 17.966%, and Collaboration and Communication is 16.379%. (Table 3).



"Scree Plot"

Table. 4 "Rotated Component Matrix"

S. No.	Statements	Factor Loading	Factor Reliability
	Adaptability and Flexibility		**.953**
1.	Startups quickly adapt to changing needs of customers	.950	
2.	Strategies are modified rapidly in response to market uncertainty	.897	
3.	Employees are flexible in handling unexpected situation	.860	

4.	Innovation helps in responding effectively to dynamic business environment	.855	
	Complexity Management		**.959**
1.	Business effectively handles complex business situation	.956	
2.	Management can identify inter-related challenges within the organization	.906	
3.	Team collaborate effectively to solve complex problems	.892	
4.	Organizations can manage rapid changes without major disruptions	.882	
	Strategic Decision-Making		**.882**
1.	Strategic decisions consider multiple perspectives	.923	
2.	Data and insights are integrated before major decisions are made	.871	
3.	Decision-making processes are aligned with organizational goals	.811	
	Collaboration and Communication		**.831**
1.	Departments communicate effectively with one another	.935	
2.	Information flows smoothly across organizational levels	.929	
3.	Collaboration improves ability to handle uncertainty	.633	

Factors of the study and its related variables

The first factor of the study is Adaptability and Flexibility, the variables it includes are Startups quickly adapt to changing needs of customers, Strategies are modified rapidly in response to market uncertainty, Employees are flexible in handling unexpected situation and Innovation helps in responding effectively to dynamic business environment. Complexity Management is the second factor, the variables are Business effectively handles complex business situation, Management can identify inter-related challenges within the organization, Team collaborate effectively to solve complex problems and Organizations can manage rapid changes without major disruptions. Strategic Decision-Making is the third factor, it includes variables like Strategic decisions consider multiple perspectives, Data and insights are integrated before major decisions are made, and Decision-making processes are aligned with organizational goals. Last and fourth factor is Collaboration and Communication, its variables are Departments communicate effectively with one another, Information flows smoothly across organizational levels and Collaboration improves ability to handle uncertainty

Table 5 "Reliability Statistics"

"Cronbach's Alpha"	"Number of Items"
.893	14

Total reliability of 14 items that includes variables for the "examining the Role of Systems Thinking in Managing Complex Adaptive Systems in Indian Start-ups" is 0.893 (Table 5).

"Table 6 Model Summary"

"Model"	"R"	"R Square"	"Adjusted R Square"	"Std. Error of the Estimate"
1	.838[a]	.702	.697	.41937
Predictors: (Constant), Adaptability and Flexibility Complexity Management Strategic Decision-Making Collaboration and Communication				

The adjusted R-squared value is 0.697 with approximately 70% of the variation.

"Table 7 ANOVA"

"Model"		"Sum of Squares"	"df"	"Mean Square"	"F"	"Sig."
1	"Regression"	98.644	4	24.661	140.221	.000[b]
	Residual	41.858	238	.176		
	Total	140.502	242			
a. Dependent Variable: Overall impact of Systems Thinking on Managing Complex Adaptive Systems						
b. Predictors: (Constant), Adaptability and Flexibility Complexity Management Strategic Decision-Making Collaboration and Communication						

Value under significant column indicates a significant relationship between "Adaptability and Flexibility Complexity Management Strategic Decision-Making Collaboration and Communication" and Managing Complex Adaptive Systems.

"Table 8 Coefficients"

"Model"	"Un standardized Coefficients"		"Standardized Coefficients"	"t"	"Sig."
	"B"	"Std. Error"	"Beta"		
(Constant)	3.955	.027		147.001	.000
Adaptability and Flexibility	.338	.027	.444	12.554	.000
Complexity Management	.088	.027	.116	3.278	.001
Strategic Decision-Making	.244	.027	.320	9.056	.000
Collaboration and Communication	.475	.027	.623	17.622	.000
DV: Overall impact of Systems Thinking on Managing Complex Adaptive Systems					

All the factors Adaptability and Flexibility Complexity Management Strategic Decision-Making Collaboration and Communication are showing significant impact on Managing Complex Adaptive Systems. Highest impact is shown by Collaboration and Communication with beta value .623 followed by Adaptability and Flexibility (.444), Strategic Decision-Making (.320), and Complexity Management (.116).

Conclusion

Systems thinking serves a significant role in assisting businesses comprehensively and handle the intricacy of contemporary business environments. Indian startups function within a dynamic ecology where ambiguity, swift technological advancements and interrelated connections notably affect organizational performance. By seeing startups as Complex Adaptive Systems, this research emphasizes the significance of adaptability, corelation, association, and universal decision-making.

The research displays that systems thinking assists startups improvise flexibility, modernization, and long-term sustainability by fostering adaptive knowledge, identifying several perceptions, and comprehending system-wide networking. Moreover, modern technologies like artificial intelligence and virtual reality are revolutionizing administrative wisdom, interaction, and decision-making practices, creating adaptive systems methods highly pertinent to startup ecosystems (Yadav et al., 2023). In a swiftly revolutionizing digital and entrepreneurial environment, systems-based practices are extremely imperative for productive organizational management and sustainable development (Lu, 2026). Moreover, flexibility-based and reformative innovative methods reinforce the capability of startups to sustain and develop within a cutthroat market (Yadav & Yadav, 2024). Altogether, systems thinking facilitates a systematic structure for handling intricacies and assisting sustainable development within Indian startups functioning as complex adaptive systems.

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