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A Systems Perspective in Examining Industry Clusters: Case Studies of Clusters in Russia and India

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Abstract: This article explores an examination of industry clusters from a systems perspective. We analyze Russia's pharmaceutical clusters and India's automobile clusters in terms of the systems concepts of holism, emergence, and open systems. We further consider the aspects of human capital investment and the availability of professional labor, infrastructure, private–public sector collaboration, support for funding and commercialization, as well as innovation corporate culture, when examining the institutional pillars supporting the development and growth of industry clusters within the national innovation ecosystems. The findings illustrate how industry clusters can be viewed from a systems perspective. We also highlight how the institutional pillars underpinning national innovation ecosystems can be applied to an industry cluster level, particularly in emerging countries. The article provides implications for theory and practice in the application of a systems perspective as a way to foster industry cluster innovation and promote a more effective national innovation ecosystem.

Keywords: systems perspective; industry clusters; national innovation ecosystems; holism; emergence; open systems; innovation; Russia; India



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1. Introduction

Industry cluster innovation plays an important role in the economic development of nations (Porter 2000; Zhao et al. 2010). While studies on the emergence of newly industrialized countries (NICs) such as Hong Kong, Singapore, South Korea, and Taiwan, focus on the extent of innovation in these countries, it is the industrial agglomeration to form clusters that provides capacity-building and skill-development for the formation and upgrading of industries in these countries. Industry clusters become the pillars that support industries' research and development (R&D) activities in fostering product and process innovation and upgrading technologies (Callois 2008; Tsuji and Kuchiki 2010). Indeed, clusters stimulate the development of new industries and are also increasingly viewed as the driving force in knowledge creation, and as magnets for foreign direct investment (Porter 2000).

Porter (2000) describes industry clusters as concentrations of interconnected institutions and companies that are geographically close, operating in similar or related industries, and linked by complementary elements. While the topic of industry cluster innovation has received some scholarly attention (Giuliani 2013), the systemic view of such industry clusters has not been investigated. Industry clusters offer an economic advantage as there is a concentration of resources, skills, and labor as well as technological and knowledge spillovers (Ter Wal 2013). Industry clusters are also a part of a national innovation ecosystem (NIE) (OECD 1999; Edquist 2005) where actors, networks and supporting institutional

pillars enable value creation and innovation. Such clusters do not operate in isolation. They are part of the bigger system of interactions between organizations, government, research institutions, educational institutions, and other stakeholders. This brings us to formulate two research questions that have not been extensively explored in the existing literature: (1) How can industry clusters be viewed from a systems perspective? (2) How does a model of national innovation ecosystem (NIE) apply to industry cluster innovation?

We focus on examining industry clusters from a systems perspective, investigating holism, emergence, and openness (Suseno and Standing 2018) and focusing on the three broad aspects of actors, networks, and the institutional pillars of NIE. NIE is critical in understanding industry clusters because such clusters are embedded within the boundary of a country with specific institutional contexts. There are many actors that are interdependent and yet continuously interacting and forming networks within the ecosystem. In this study, we consider the five pillars of the NIE: human capital and the availability of professional labor, infrastructure, private–public sector collaboration, support for funding and commercialization, and innovative corporate culture (Jackson et al. 2017), in examining industry clusters. Consequently, our study provides interesting and more comprehensive insights into how clusters are structured and managed in order to facilitate innovation.

The study contributes to the literature in threefold. First, with a lack of studies examining industry cluster innovation, this study contributes by applying the systems perspective of industry cluster innovation. Second, in examining industry clusters, we focus on a framework of analyzing actors, networks, and the institutional pillars of an ecosystem. Third, the study is focused on further understanding innovation from emerging economies (Metcalf and Ramlogan 2008). Extant research on national innovation and clusters has largely focused on developed countries or regions (e.g., Mudambi et al. 2017). While there are several studies on innovation from the developing countries, they are mainly concentrated on China (He and Rayman-Bacchus 2010). In this study, we focus on industry clusters in two transition and emerging economies, namely Russia's pharmaceutical industry clusters and India's automotive industry clusters. The cases of both Russia and India are relevant as these countries play an increasingly important role in today's economy. We focus on two specific industry clusters, i.e., pharmaceutical, and automotive, as they are particularly critical to the growth of these respective nations. With limited research examining industry clusters in Russia and India, this topic therefore deserves further investigation.

2. A Systems Perspective of Industry Cluster Innovation

The systems perspective to innovation has been examined at different levels: regional (e.g., Bell et al. 2009; Dobusch and Schüßler 2012), sectoral (Calvert and Senker 2004), and national (e.g., Jackson et al. 2017). While extant studies have examined the effect of industry clusters on innovation (e.g., Casanueva et al. 2013), a systems perspective of industry clusters is still lacking in the literature, and yet innovation is underpinned by the interactions of firms within such system. These clusters then enable incremental and radical innovation for the growth of an economy (He and Rayman-Bacchus 2010; Porter 2000; Nazarov and Klarin 2020). An early study by Saxenian (1994), for example, highlights the differences in the regional structure and entrepreneurial culture of Silicon Valley and Boston. Silicon Valley eventually displaces Boston to become the cluster of technology start-up firms, driving the booming economy of the area (Nicholas and Lee 2012). In much the same way, countries also promote industry cluster development for innovation. For example, Singapore has developed knowledge-based industry clusters such as the biomedical sciences cluster and the offshore marine engineering cluster, to compete with other countries and to sustain the nation's growth (Wong et al. 2010).

The systems perspective is essentially underpinned by three important pillars of holism, emergence, and openness. Holism is important as there are interactions between parts of a system. Thus, sub-optimization will not produce the most optimal outcome for the system (Jackson 2003, 2006). In other words, holism avoids merely focusing on

just several features of the system (Suseno and Standing 2018), but rather emphasizes the importance of relationships between components of the system.

The second characteristic of the systems perspective is emergence, defined as “the principle that entities exhibit properties which are meaningful only when attributed to the whole, not to its parts” (Checkland 1999, p. 314). An emergent system behavior can be attributed to the interactions between the elements of the system. Page (2009) considers three types of system emergence in terms of simple, weak, and strong. A simple emergence usually occurs from the interactions between elements in a non-complex system and this type of emergence can be predicted. A weak emergence occurs due to the interactions and relationships between the components of a complex system, and this type of emergence is predictable. The last type of emergence is strong emergence where the emergence is unexpected and often not at all anticipated in the planning or development stage.

The third characteristic of a systems perspective is the concept of openness. The underpinning idea of openness is that systems have permeable boundaries and consequently such systems affect, and are influenced by, the environments (Emery 2010; von Bertalanffy 1950). For example, a nation needs to develop an open systems platform for innovation by maximizing its interactions with its external and internal environments (Standing et al. 2018).

Industry clusters need to be viewed from a holistic perspective (Jackson 2006). Firms within an industry cluster achieve synergies from the interactions and collaborations with each other. Clusters enhance innovation through positive externalities in terms of infrastructure development that attracts suppliers and highly skilled employees (e.g., Malmberg and Power 2005) as well as the creation of technological and knowledge spillovers (e.g., Liao 2015; Ter Wal 2013). Viewing it in a holistic manner, we consider the actors and their networks as well as the institutional pillars to evaluate industry clusters: human capital and the availability of professional labor, infrastructure, private–public sector collaboration, support for funding and commercialization, and innovative corporate culture (Jackson et al. 2017).

Industry clusters also need to be adaptive to changes in the environment. The dynamics of emergence suggest that systems need to continuously adapt to various changes when interacting with the environments. An industry cluster can emerge as a result of government policy or restructuring programs or they can emerge as a result of initial manufacturing clusters that were previously established (Roberts and Enright 2004; Ray and Ray 2021). An industry cluster also needs several years to evolve and is dynamic. For example, in South Korea, clusters made up of industrial parks were initially developed to promote light-industry exports, but since the 2000s, South Korea’s government policy had ensured that these clusters became specialized clusters (urban, high-tech industrial parks and foreign investment zones) to promote and sustain innovation (Kim 2015). Roberts and Enright (2004) further highlight that industry clusters, particularly those in regional economies, emerge under some form of government policy/reforms or a partnership with industry. The sharing of ideas and knowledge, as well as the patterns of competition and cooperation within an industry cluster, essentially facilitate a structural change for an evolving, emergent industry cluster system.

In addition, industry clusters need to be open to absorb, transfer and create knowledge. An open cluster enables the mobility of highly-skilled individuals, promotes collaborative interaction (Malmberg and Power 2005) and facilitates global sourcing of knowledge production (Manning 2013). An open cluster also promotes mutuality for example in terms of promoting university–industry collaboration (Jackson et al. 2017). An open industry cluster essentially enables knowledge networks, resources, relationships and learning with organizations within and external of the cluster. As noted by Landry and Amara (1998, p. 274), “innovative firms develop more interactions with outside sources of ideas, information and technology than non-innovative firms do.” Indeed, an open system is considered to facilitate innovation because of the interactions for ease of access to, and the creation of, knowledge (Laursen and Salter 2014; Standing et al. 2018).

3. Methodology

An exploratory case study approach is adopted in this study to examine the pharmaceutical industry and automotive industry clusters in transitional and emerging economies, Russia and India respectively, from a systems perspective (Eisenhardt 1989; Yin 2009). The case study design is appropriate for this endeavor as a case study enables an in-depth insight into the context (Dyer and Wilkins 1991). Moreover, a case study approach can provide a more convincing demonstration of conceptual argument (Siggelkow 2007; Silverman 2013).

The first case is of the pharmaceutical industry cluster which is one of the fastest-growing industries in the world, driven by technological innovation, specifically focusing on the pharmaceutical clusters in Russia. We analyzed published materials such as journals, books, and industrial websites on the pharmaceutical industry of Russia. For the second case study, we examined the case of India's automotive industry clusters which is one of the strategic sectors of the Indian economy and one of the world's fastest-growing passenger car markets. Similarly, we reviewed secondary data from a variety of sources including journals and books, newspaper articles, and various industry publications.

We consider Yin's (2009) criteria for evaluating the secondary data of our research. Construct validity in case study research emphasizes that a specific context being studied is well-described and examined in detail. This requires using multiple sources of evidence (Yin 2009) and we applied this in the context of both the Russian pharmaceutical and Indian automotive clusters. The use of both cases also allows for within-case analysis coupled with a cross-case analysis of similarities and differences between cases to generalize patterns across cases (Baxter and Jack 2008). This ensures the internal validity and reliability of the study for consistency of analysis within and across cases (Bennett and Elman 2006) as the study was not solely based on limited information from a single case (Yin 2009). Finally, the findings were compared with existing literature, ensuring the external validity of this research (Ahrens and Chapman 2006).

4. Case Study 1: A Systems Perspective of Russia's Pharmaceutical Industry Clusters

In 2009, the Russian Ministry of Health (MOH) introduced the 'Strategy of Development of the Pharmaceutical Industry of the Russian Federation to 2020' (hereafter, Pharma 2020), which aims to consolidate the state of the pharmaceutical industry. In 2009, only 16.4% of the vital and essential drugs (VEDs) were manufactured locally, but this increased to 84% at the end of 2017 (Dobrovolskij 2017). The government's push for the localization of production resulted in a wave of inward foreign direct investments (FDIs) by world-leading pharmaceutical companies (Big Pharma) establishing wholly owned subsidiaries in Russia. Notable foreign and local collaborations further led to localized production, including for example Abbott with Veropharm, GlaxoSmithKline with Binnopharm, Pfizer with ChemRar, Merck with Akrikhin, and Roche with TeaRx (Klarin and Ray 2019). This 'changing' of the investment climate promoted the emergence of networks and innovation.

The country hosts 25 innovative territorial clusters that are financially subsidized by the Russian Ministry of Economic Development (MED). Six of these are medical and pharmaceutical technologies clusters (Table 1). Kaluga pharmaceutical cluster, as an example, conducts full-cycle production of substances and finished medicines from R&D to distribution. The other main actors are the Big Pharma players including Novo Nordisk, AstraZeneca, Berlin-Chemie, a number of Russian collaborators, two universities, and three research Institutes (RIs), totaling 63 members. The cluster employs over 10,000 specialists, manufactures 154 finished products, with total investment exceeding US\$1 billion since 2011 (Kaluga Pharmaceutical Cluster 2018).

Table 1. Russia’s pharmaceutical clusters.

Region	Cluster Title	Companies Present	Estd.	Members	Staff
Kaluga region	Pharmaceutical, biotechnology and biomedical cluster (Obninsk)	AstraZeneca, Novo Nordisk, Stada, Pharm-Sintez, Nearmedic, Berlin-Chemie, Mir-Pharm, PharmVILAR, Berahim, Medbiopharm, various RIs	2012	63	10,500
Moscow region	Biotechnological innovative territorial cluster Pushchino	Valenta, Russian Academy of Sciences (RAS) GRIs, Moscow State University (MSU), Deost, Diakon-Lab, DNA-Technology, Rafarma	2012	68	8706
Moscow region	Cluster “Phystech XXI” (Dolgoprudny)	Protek, Chemrar, Moscow Institute Of Physics And Technology (MIPT), Akrikhin, Geropharm, Janssen, various RIs	2012	30	46,075
St. Petersburg	Cluster of medical, pharmaceutical, radiation technologies of St. Petersburg	Aksi-group, Valenta, Infomed, Lumex, Nephron, Biocad, Biotech, Verteks, Geropharm, Cytomed, Polysan, Rosbio, Farmacor, Pharmasyntez, various RIs	2011	166	3626
Altai	Altai biopharmaceutical cluster	Evalar, Altaivitaminy, ALMA, Vostokvit, Dve linii, Kit, Altamar, Galen, Malavit, Yug, Altay buket, Altay len, RAS GRIs	2008	24	2532
Tomsk region	Smart Technologies Tomsk	Pharmstandard, Biolit, Nanokor, Solagift, Elekard-Med, Medpribor, MedAzimut, BioSense, Diagnostika Plus, various RIs	2013	52	12,622

Sources: Ministry of Economic Development of Russia (2012); Altai Biopharmaceutical Cluster (2018); Center for Cluster Development of Tomsk Oblast (2018); Kaluga Pharmaceutical Cluster (2018); Korporatsiya Razvitiya Moskovskoy Oblasti (2018); National Research University—Higher School of Economics (2018); Northern BioPharmCluster at MIPT (2018); Technopark of Saint-Petersburg (2018).

The Russian pharmaceutical structure consists of various overlapping clusters and associations, and within these overlaps, the Kaluga Pharmaceutical, St. Petersburg Pharmaceutical and Biomedical, and Biopharmcluster “Severniy” clusters have joined the Union of Pharmaceutical and Biomedical Clusters (UPBC) which is a part of the Association of Innovative Regions of Russia (AIRR). There is also the Association of Clusters and Technology Parks (ACTP) established in 2011, representing the interests of more than 2500 organizations, including the residents of technology parks and industrial cluster members (Association of Clusters and Technology Parks 2017). The UPBC’s government relations are managed through the AIRR, the Association of Russian Pharmaceutical Producers (ARFP), and the Association of International Pharmaceutical Manufacturers (AIPM) (Figure 1).

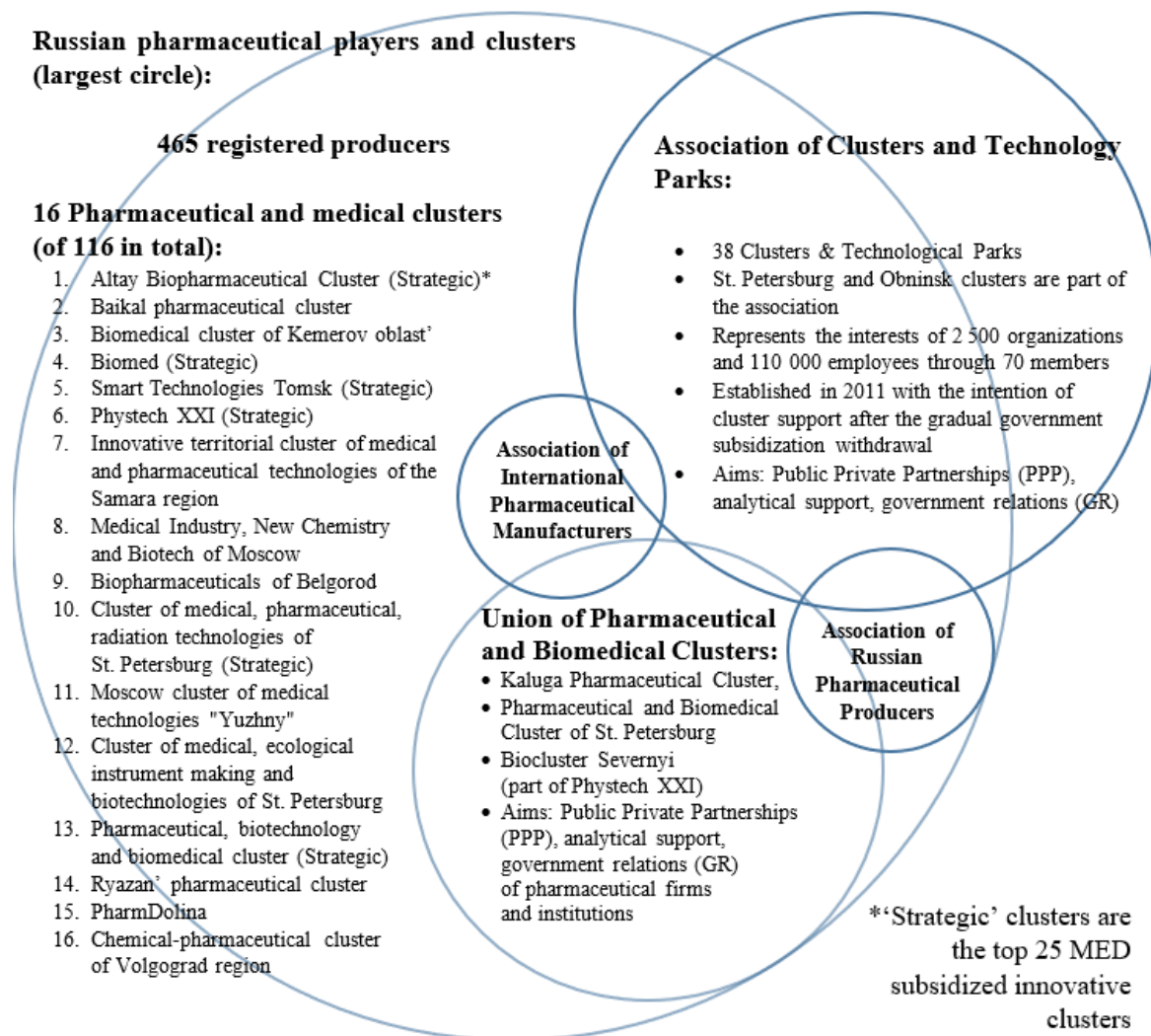


Figure 1. The networks of Russia's pharmaceutical clusters, firms and associations. Sources: Association of Clusters and Technology Parks (2017); Association of Russian Pharmaceutical Producers (2016); Ministry of Economic Development of Russia (2012); National Research University—Higher School of Economics (2018).

We argue that the institutional pillars of the NIE can be used to examine industry cluster innovation, as clusters are made up of actors and networks, supported by institutional pillars to develop and expand. The following section details human capital investment and the availability of professional labor as one of the institutional pillars of an industry cluster.

4.1. Human Capital Investment and Availability of Professional Labor

The top-down education system of planned economies such as Russia emphasized the centralization aspect of education where the ultimate control lies with the state. However, the 'perestroika' and the transition period had a negative impact on the Science and Technology (S&T) sector and its human capital. The shortage of skilled personnel is evident in the pharmaceutical sector as the industry requires talented employees with a high level of education in the pharmaceutical sciences. Prior to 2010, there were virtually no programs for specialist training in modern pharmacology due to low demand, as companies were reluctant to fund long-term investment projects (Balashov 2012). Scientific professions in Russia were relatively low paid, forcing professionals to emigrate or switch to different industries or specializations. This was exacerbated by outdated materials and low technological bases of institutions due to their relatively poor financial situations. Consequently, graduates were ill-prepared in knowledge and competencies, which resulted

in the low supply of specialists in the industry, thus preventing the emergence of innovation (Gordeev 2009).

Realizing the potential barriers to an open and emergent system of innovation, the Russian Ministry of Health adopted a holistic approach by making it mandatory for all students of medical and pharmaceutical educational bodies to undergo compulsory internships in relevant fields (MED 2016). Such internships build linkages and networks that facilitate open innovation. Industrial cluster creations also add to favorable conditions to attract and retain qualified specialists (Soboleva and Zhivotova 2013). The government's holistic approach resulted in increased skilled labor, enabling the emergence of ideas and solutions in the industry. In 2010, 83% of Russian pharmaceutical firms acknowledged skill shortage as a major concern, but by 2017, only 5% indicated as much (Deloitte CIS 2017).

4.2. Infrastructure

The holistic approach adopted by the Russian government in recent years provides support for domestic industrial development. This creates an emergence of a more efficient competitive innovation-based industry. Being a key strategic industry, the Russian pharmaceutical industry faced an overhaul in the late 2000s, with the introduction of various initiatives including the Federal Law 'On Circulation of Medicines 2010' (State Duma 2010), and new bodies such as the Federal Service for Surveillance in Healthcare (Roszdravnadzor). The Department of State Regulation of Medicines, in conjunction with Rospatent, also became responsible for the registration of new medicines and was given clearer responsibilities and powers (Balashov 2012). In addition, the government invested about 3.3% of the country's GDP in the industry between 2011 and 2017 and plans to increase this to 4–5% (Government of the Russian Federation 2018).

The Ministry of Industry and Trade (MIT), the MED and the MOH were tasked to boost domestic self-sufficiency and productivity of the pharmaceutical sector. Clusters, often based in special economic zones (SEZs), were formed throughout Russia, attracting firms and high skilled personnel by providing preferential treatment including the reimbursement of R&D expenditure, modernization of plant and equipment, reduction of taxes, development of infrastructure, media promotion, and provision of simplified migration and customs regimes, tax subsidies in SEZs, as outlined in Table 2.

Table 2. Tax privileges of the SEZ clusters in Russia.

Tax Exemption	Technology Innovative SEZs' Tax Rates	Normal Tax Rates
Federal profit tax	0% (from 2012–2018)	3.0%
Regional profit tax	0–13.5% (depending on the region)	17.0%
Value added tax	18% (0% if delivered inside the SEZ)	18.0%
Property tax	0% of up to 10 years	2.2%
Land tax	0% of up to 5 years	1.5%
Transport tax, \$ per hp	0% of up to 10 years	\$0.4 and higher
Pension fund payment	8–20% in 2017–2019	22%
Social insurance fund	2–2.9% in 2017–2019	2.9%
Health insurance fund	4–5.1% in 2017–2019	5.1%
Total	14–28% in 2017–2019	30%

Source: Association of Clusters and Technology Parks (2017).

Sources of open innovation are often derived from industry clusters (Chesbrough et al. 2006). The networks formed within the pharmaceutical industry clusters facilitate open innovation and the emergence of innovations. For example, a partnership between Roche and the Centre of High Technologies "ChemRar" in creating an innovative company 'Viriom', enables the development of medicines in the field of HIV infection, hepatitis C and B and other infections (Viriom 2017). Another example of a productive outcome is the AstraZeneca and Skolkovo cluster that established Start-up Challenge 2018 to support start-ups involved in innovative projects, such as cardiovascular, respiratory, and autoimmune diseases (Technopark Skolkovo 2018). The introduction of a new law permitting the retail

sale of medicines on online platforms also creates a strong emergence as there are changes not only in terms of new products, but also changes in the supply chain, operations, and the business environment of the pharmaceutical industry in Russia. The government has therefore adopted a more holistic view of building infrastructure to enable actors in the industry to form networks and facilitate strong growth for the emergence of the pharmaceutical sector.

4.3. Private–Public Sector Collaboration

With the introduction of the strategic industry roadmaps in the 2010s, the government initiated the development of SEZs and clusters that provided support for innovation and production via collaborations between the RIs, academia, and the private sector. The representation of these clusters is done through direct links to the government as well as through institutions such as the UPBC and the AIRR. The traditional Soviet and post-Soviet separation of academia, the public sector, and industry is therefore no longer instituted and is increasingly replaced by tripartite relationships, facilitated further by the presence of foreign firms.

As part of Pharma 2020, the MIT is tasked with responsibilities that include the formation and implementation of the state policy and legal regulations, the identification of priority areas for innovation, and the protection of economic interests of Russian manufacturers (MIT 2018). The MIT is funding the construction of new biomedical centers and laboratories to facilitate open innovation. These various initiatives trigger private–public sector collaboration for the emergence of innovative outcomes. As an example, Nanolek biopharmaceutical company now operates from the campus of Vyatka State University, and the two closely cooperate in training specialists and in carrying out joint R&D (Stolitsa Moskva 2017).

The MIT is also responsible for ensuring cooperation with various associations and unions including the UPBC which represents several pharmaceutical clusters, AIRR, ARFP, and AIPM, as well as with various clusters and key actors in the industry (see Figure 1). The MIT's role is therefore related to institutionalizing a complex set of institutions and regulations to provide a holistic approach to managing the sector.

4.4. Support for Funding and Commercialization

The Russian government has been supporting the local manufacturing of pharmaceutical products. This can be evidenced in the introduction of regulations against imported goods and an annual price increase of 6% on imported VEDs (DSM Group 2014). Additionally, the government demands a 15% discount on medicines produced outside Russia when these companies participate in government tenders. Moreover, the government provides up to 50% reimbursement of clinical trials and/or procurement of capital machinery if these are made domestically within the first three years (Government of the Russian Federation 2018).

The government also introduced various schemes for the preferential treatment of local producers in government procurement programs. It created clusters with preferential policies in terms of tax and reimbursement for innovative companies, as shown in Table 1 earlier. From 2011, SEZs received preferential subsidies including corporate tax reduction to 13.5%, and innovative clusters were exempt from income, property, and transport tax for 10–15 years. Support for funding and commercialization from the top highlights the holistic approach of the government, allowing domestic manufacturers to expand and facilitating the emergence of the development of new products domestically.

4.5. Innovative Corporate Culture

With the cost of a breakthrough medicine purportedly around US\$5 billion (Herper 2013), research has shown that firms in high-tech industries engage in open innovation models (Gassmann et al. 2010; Schuhmacher et al. 2013). This applies to the pharmaceutical industry where such initiative as corporate culture is driven by the high costs of research laboratories, the fast pace of technological development, the difficulty in employing and retaining high-skilled personnel and the increasing R&D and manufacturing costs. Firms are becoming more open to sharing, licensing, and partnering with other firms, which inevitably leads to a more collaborative environment, in contrast to the traditional closed in-house R&D and production. This allows for the dissemination of knowledge and technologies across partners, flows of ideas and research between and within companies.

The Russian government has attempted to create an innovative culture of openness through the formation of strategic territorial clusters and technology platforms (Cheshev 2010; Gokhberg and Kuznetsova 2011). Clusters create network links between large organizations, SMEs, RIs, tertiary institutions, various levels of governments and even start-ups to engage in collaborative ventures where actors can specialize within the value chain. The Soviet culture of secrecy and the distinct separation of industry and academia are long gone, replaced by the increasing realization that open innovation actors, governments, associations, and other institutions are needed to be globally competitive. Domestic actors within clusters are also partnering with foreign firms or even acquiring others to gain benefits from open innovation. The effectiveness of the government-led cluster creation can be illustrated by the productivity of one of the subsidized strategic innovative clusters, namely the St. Petersburg pharmaceutical cluster, which shows an average yearly increase of 69% in 2016, as shown in Table 3.

Table 3. Sales volume of St. Petersburg pharmaceutical cluster (Rub, mln.).

	2010	2011	2012	2013	2014	2015	2016	Total % Change	Yearly % Change
Biocad	1551.9	2251.3	2412.6	2347.3	2731.7	8620.9	13,033.6	739.8	105.7
Polisan	1105.5	1457.7	1759.7	1984.3	3065.9	2983	3540.1	220.2	31.5
Vertkeks	880.7	1184.4	1268.5	1239	1490.7	2535.8	3981.3	352.1	50.3
Samson-med	151.8	155.8	180.3	178.4	192.1	209.2	185.3	22.1	3.2
Cluster total	5187.5	6871.2	9811.3	11,020.2	13,409.7	22,296.7	30,184.3	481.9	68.8

Sources: Lin and Ivanov (2017); Sokolova et al. (2017).

Government control over the ailing pharmaceutical industry in the 2010s enables the overhaul of the industry. It attempts to create a stronger national innovation ecosystem based on the modernization and collaborations of the pharmaceutical innovation clusters of the country. The government control provides a holistic understanding of the industry, and its cluster development promotes human capital and the availability of professional labor, infrastructure, private–public sector collaboration, support for funding and commercialization, and innovative corporate culture (Jackson et al. 2017). The actors also form network links to others within, and outside of, the clusters to facilitate the emergence of innovative products and processes through adopting open structures, a concept that was previously unheard of in Russia. The details of the institutional pillars structuring and managing innovation in the Russian pharmaceutical clusters are shown in Table 4.

Table 4. The systems perspective of Russia’s pharmaceutical clusters.

Aspects of Innovation System	Holism	Emergence	Open Systems
Human capital and availability of professional labor	<ul style="list-style-type: none"> - History of strong education system in science (+) - Encouragement and support for education in pharmaceutical sciences (+) - Education system in S&T is weakening according to international standards (-) 	<ul style="list-style-type: none"> - Creation of new higher degree disciplines (+) - Introduction of postgraduate training programs for validation and quality audits (+) - Private sector offers education for aspiring students (+) - Brain drain (-) - Despite government efforts, the lack of skilled personnel in industry remains (-) - Education system is in Russian language (-) 	<ul style="list-style-type: none"> - Increasing collaboration between local and foreign firms as well as academia (+) - Exchange programs development (+) - Hostilities with a number of countries (-) - Travel difficulties to and from Russia (-)
Infrastructure	<ul style="list-style-type: none"> - Increased attention to intellectual property protection (+) - Emphasis on innovation commercialization (+) - Investment in chemical and pharmaceutical research by the government (+) - The lack and underdevelopment of laws and regulations (-) - Red-tape and corruption (-) - Infrastructure is still weak in comparison to developed countries (-) 	<ul style="list-style-type: none"> - Improving competitiveness of scientific developments from the private sector (+) - Private sector creates an environment conducive to innovation development (+) - Increased competition (-) 	<ul style="list-style-type: none"> - Creation of effective clusters (+) - Increasing levels of collaboration between firms (+) - AIPM and ARFP work closely with the government as informed lobby groups (+) - Trade, investment, and collaboration restrictions (-)
Private-public sector collaboration	<ul style="list-style-type: none"> - Favourable policy environment to attract foreign MNCs (+) - Focused government initiatives to promote collaboration e.g., building and redeveloping a number of pharmacy-related institutions (+) - Overreliance on MNCs to innovate (-) 	<ul style="list-style-type: none"> - Joint product development between industry and universities, industrial training institutes (+) - The National Drug Insurance scheme makes the government a large consumer for the largest companies, thus creating stronger links between the state and the manufacturers (+) 	<ul style="list-style-type: none"> - ARFP, AIPM and manufacturers are lobbying for support (+) - Increasing collaboration from the private and public sectors (+) - Collaboration is still in infancy stage (-)

Table 4. Cont.

Aspects of Innovation System	Holism	Emergence	Open Systems
Support for funding and commercialization	<ul style="list-style-type: none"> - The state is an overseer and provides tangible support for the industry (+) - Government invested, on average, 3.6% of GDP to the industry (US\$1.8 billion) annually (+) - Funding support at every entrepreneurial stage from R&D to commercialization (+) - Insufficient financing for the hospital segment and the state reimbursement program manufacturers (-) 	<ul style="list-style-type: none"> - Financial incentives for R&D (+) - Investment in R&D by technology leaders (+) - Lack of support for companies not in the lead (-) 	<ul style="list-style-type: none"> - MIT plans to support 20 innovative drug and medical equipment centres (+) - Many funding schemes are open access (+) - Further collaboration between university and businesses is required (-) - Funding schemes are prone to corruption (Deloitte CIS 2017) (-)
Innovative corporate culture	<ul style="list-style-type: none"> - Development of multiple pharma clusters (+) - Various government initiatives to create an innovation ecosystem (+) - Distrust, risk aversion and follower mentality are prevalent (-) - Lack of capital prevents innovation (-) 	<ul style="list-style-type: none"> - Modernization, internalization, acquisitions and collaborations for innovativeness and sustainability (+) - Leading companies look outside the country for expansion (+) 	<ul style="list-style-type: none"> - Increasing levels of collaboration between firms (+) - Government policies to promote innovation and collaborations (+) - Underdeveloped open innovation system (-)

5. Case Study 2: A Systems Perspective of India’s Automotive Industry Clusters

The liberalization and the adoption of the New Economic Policy in 1991 opened up the Indian economy, and had significant consequences for India’s automotive industry development (Chettri 2002). The key policy decisions of removing the automotive import quota, de-licensing, relaxing the taxes on the import of capital goods, and expanding the technology and capacity of auto manufacturers transformed the industry into a dynamic sector. The ‘Auto Policy’ was a key strategy adopted by the Ministry of Industry to make India a global manufacturing hub for small passenger cars (Rao 2008). Such policy changes transformed the formerly monopolistic passenger car segment into one of the most competitive industry sectors in India.

India has five auto clusters, providing the basis of skilled labor and supporting infrastructure, and fueling the growth of the sector (Okada and Siddharthan 2008). These five auto clusters are (1) Chennai, Tamil Nadu cluster, (2) National Capital Region (NCR) cluster, (3) Chakan, Maharashtra cluster, (4) Sanand, Gujrat cluster, and (5) Pithampur, Madhya Pradesh cluster. The share of the main actors of the total automotive market is illustrated in Figure 2, while firms, clusters, and networks of these clusters are illustrated in Figure 3.

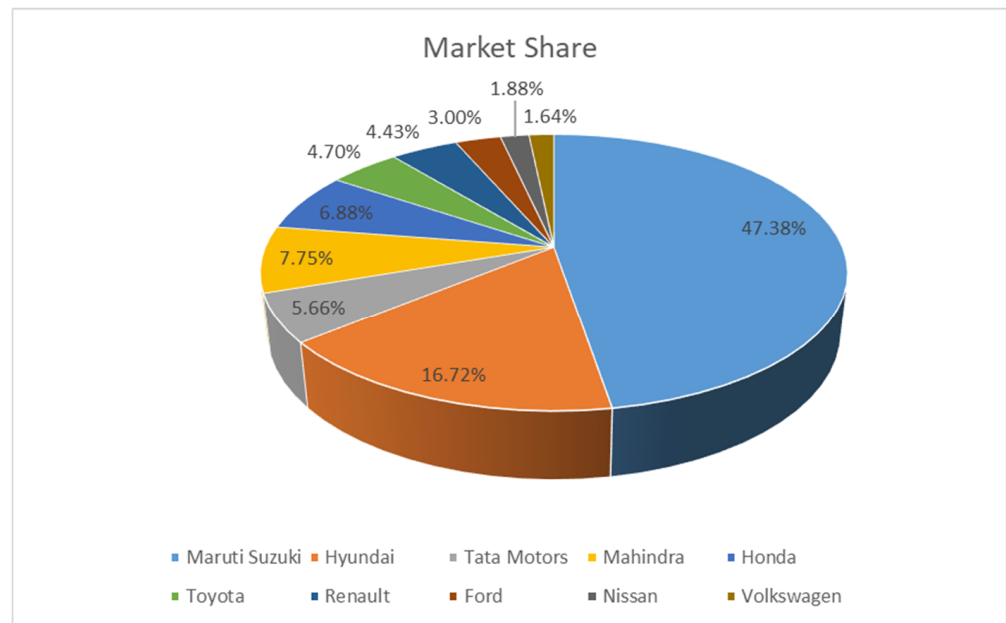


Figure 2. Main actors in India’s automotive clusters (passenger vehicle category). Source: Adapted from the [Economic Times \(2017\)](#).

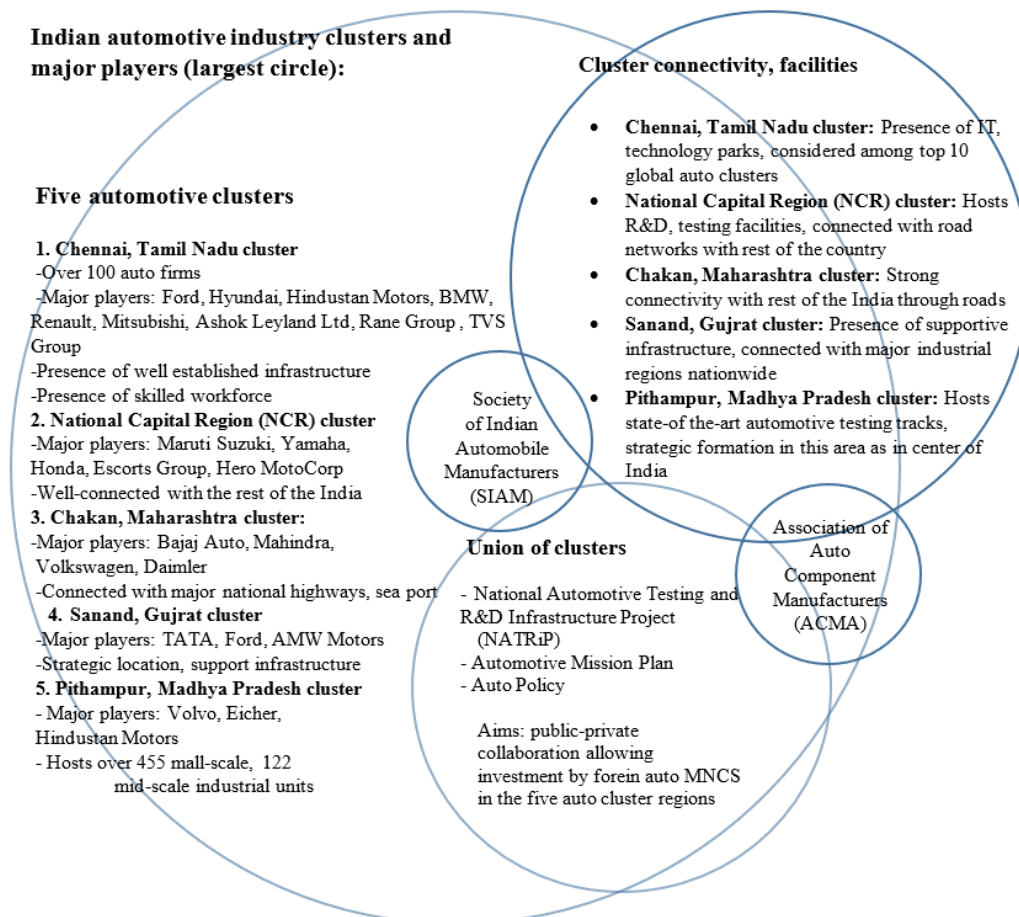


Figure 3. The networks of India’s automotive clusters, firms and associations. Sources: [ACMA \(2018\)](#); [Okada and Siddharthan \(2008\)](#); [SIAM \(2018\)](#).

The Chennai, Tamil Nadu cluster was formed due to the availability of technical graduates and superior infrastructure facilities including Information Technology (IT) and auto technology parks. The National Capital Region (NCR) cluster is located in the northern part of India in three states, namely Delhi, Haryana, and Uttar-Pradesh (EY 2016). The well-connected road network of Delhi and Haryana with the rest of the country and the 165 km long Yamuna expressway helped to form this cluster. The Chakan, Maharashtra cluster was developed due to the region's proximity to the major national highways, connecting important cities and Mumbai's Jawaharlal Nehru Port. The Sanand auto cluster is in Gujarat, which is located close to a major airport, two key seaports, a major railway station and is linked to the state highway. Such connectivity of the region makes the Sanand cluster an ideal export hub. Finally, the Pithampur cluster is located in Madhya Pradesh (EY 2016), and it is connected to a key highway linking the main industrial regions and close to the other auto clusters, including the NCR cluster.

The automotive industry is one of the strategic sectors of the Indian economy (Sharmelly and Ray 2018a), with India emerging as one of the world's fastest-growing passenger car markets and manufacturers (Mukherjee 2017). With the 'Automotive Mission Plan 2016-2026', India aims to be among the top three automotive industries in the world, contributing over 12% to India's GDP (Economic Times 2015). The next section highlights the institutional pillars of the NIE to examine the Indian automotive industry cluster innovation.

5.1. Human Capital Investment and the Availability of Professional Labor

India's investment to build the country's human capital can be evaluated based on the concept of holism. One major government initiative is the establishment of the 'National Skills Qualification Framework' (NSQF), a national, integrated education and competency-based skill framework which provides an internationally-equivalent and transparent mechanism for skill development across various sectors. The NSQF also fosters partnership with the industry by facilitating professional labor to move across education and vocational training and industry sectors. The framework, developed by the National Skill Development Agency (NSDA), an autonomous body of the Ministry of Finance, aims to harmonize the skill development efforts of the Indian public and the private sector (NSDA 2018).

To build skilled human capital for the automotive industry, technical institutions such as Industrial Training Institutes (ITI) were established to produce a large number of technical graduates (Rohit 2011). The Ministry of Skill Development and Entrepreneurship (MSDE) also provides skill-based training to youth in the automotive and manufacturing industry (National Skill Development Mission 2015). Furthermore, the government has launched 'Skill India' program to provide customized training to develop technical and soft skills such as product development management (EY 2016). A number of auto multinationals (MNCs), including Maruti Suzuki and Toyota, are also contributing to the success of the 'Skill India' program by collaborating with various ITIs to teach Motor Mechanic Vehicle (MMV) module to their graduates (Economic Times 2017). The government's commitment adopts a holistic approach, right from its education system to its industry-focused partnership to build skills for the automotive sector. Partnerships among auto MNCs and training institutes also creates an open system enabling knowledge transfer.

The holistic approach adopted by the government is further emphasized by the creation of the Automotive Skills Development Council (ASDC) to develop occupational standards in the Indian auto industry. The ASDC essentially acts as the independent testing and certifying agency for auto industry skill development by ensuring collaboration among various auto industry administration bodies. This enables the emergence of new ideas and products to support the growth of the country's automotive industry.

5.2. Infrastructure

The Indian government is committed to innovation, and this is shown in terms of its support for the development of automotive clusters. In addition, the government also expanded the infrastructure and the availability of supporting industries to the automotive industry. This shows a holistic view of the government by focusing its investment on the country's road system to enable the expansion of the automotive industry. Such infrastructure development also facilitates the emergence of new product innovations from various industry sectors such as IT that eventually benefits the country. Moreover, the interdependent networks of auto manufacturers and supporting industries located in these geographically concentrated clusters highlight a holistic system that potentially reduces the production costs and generates benefits. These include the sharing of tacit and codified knowledge, the provision of skilled labor, and the creation of opportunities for specialized inputs, production technologies, and efficient sub-contracting (Okada and Siddharthan 2008).

The government also actively recognizes the importance of improving openness in the innovation system, by establishing the Society of Indian Automobile Manufacturers (SIAM) and the Auto Component Manufacturers Association of India (ACMA). These organizations serve as umbrella bodies with representations from major foreign and local auto manufacturers, highlighting the openness of the system. The objectives of these organizations include the exchange of support programs, knowledge, and ideas for the latest automotive technologies (SIAM 2018; ACMA 2018). The creation of such an open system enables collaboration among foreign and local automotive manufacturers within and between clusters. This consequently allows for strong emergence to occur, and it further illustrates the government's commitment to ensuring the alignment of the agenda between the automotive actors and policymakers.

5.3. Private–Public Sector Collaboration

To reform the auto industry, the Indian government entered into a joint venture with Suzuki of Japan in the early 1980s, marking the beginning of the internationalization of the auto industry. The joint venture, called Maruti Udyog Limited, launched a small but fuel-efficient model, the 'Maruti 100'. Currently, Maruti Suzuki holds over 45% of the Indian auto market share (Sharmelly and Ray 2018a). Over the years, there has been an increasing number of similar partnerships and private–public collaborations fostered by the government. Various initiatives such as the 'Automotive Mission Plan' 2016–2026 as well as the 'Make in India' and 'Skill India' programs are introduced, where both local and foreign auto MNCs are required to collaborate with Indian universities to establish training centers and improve the graduates' employability skills. For example, Hyundai India, the subsidiary of Korea's Hyundai, contributed to the government's 'Skill India Program' by collaborating with over 25 industrial training institutes and vocational colleges across India (Sharmelly and Ray 2018b). Hyundai India also developed a two-year-long training program focusing on modern automotive technologies, electronics, body engineering, and power-train development, for graduates to become certified auto industry technicians (HMIL 2017). Hyundai India then recruited these graduates at Hyundai dealerships, thereby engaging the skilled human capital in its value chain activities.

Such public–private collaborative partnerships between public institutions and private auto MNCs ensures the holistic impact of education and skilled human capital required by the auto industry. The collaborative scheme not only facilitates the emergence of new product innovations, but also strengthens the openness of the innovation ecosystem. The automotive actors in the clusters engage in various activities to closely understand the Indian customer requirements by offering customized products and to attract and retain local Indian talent. In addition, the partnership with foreign automotive players enables open innovation for new product design and development to make India's automotive sector very competitive on the global platform.

5.4. Support for Funding and Commercialization

The Indian government has declared 2010–2020 as the Decade of Innovation ([Economic Times 2013](#)) and with this, several institutions and initiatives have been introduced. This includes the establishment of the National Institution for Transforming India (NITI) to drive R&D and scientific innovations, the Department of Scientific and Industrial Research (DSIR), the Council of Scientific and Industrial Research (CSIR) to conduct industrial R&D, and the National Innovation Council to foster innovation in developing R&D ecosystem ([Taplow Group 2018](#)). The ‘Start-up India Initiative’ by the Department of Industrial Policy and Promotion has also been established to provide funding and incubation for entrepreneurial and technological start-ups for the emergence of new ideas and products ([EY 2016](#)). Moreover, the Ministry of Science and Technology has introduced an industry-led initiative named ‘Technology Development Program’ (TDP) to promote technology development and R&D in various clusters including the automotive clusters ([TDP 2018](#)). Such supporting initiatives for entrepreneurship essentially present a more holistic perspective of the system.

The R&D spending for the automotive clusters grew 6.28% in 2017–2018 ([Mohile and Mampatta 2018](#)) with the government establishing, for example, ‘The Automotive Research Association of India’ (ARAI) which provides technical expertise in R&D, testing and certification ([ARAI 2018](#)). The favorable R&D incentives set by the ‘Auto Policy’ of 2002 allowed up to 100% of foreign equity investment by foreign auto MNCs. This attracted foreign companies to establish R&D centers in the cluster regions and develop networks within and between clusters, particularly with local firms and suppliers ([Ranawat and Tiwari 2009](#); [Bruche 2009](#)). The government support for funding enables a strong emergence of new ideas and commercialized R&D solutions, with the industry growing significantly in recent years.

The regulation that allows up to 100% foreign direct investment in the automotive sector signifies the importance of an open innovation system for the automotive industry sector. As an example, in the Maharashtra auto cluster, Tata Motors of India collaborated with Microsoft to conduct research on artificial intelligence and connected vehicles. Intel India has invested US\$170.59 million to expand its R&D center in the Bengaluru-Chennai auto cluster with expected completion by the end of 2018. As another example, Robert Bosch Engineering and Business Solutions (RBEI) has introduced its new reliability testing lab in the Bengaluru-Chennai cluster to test electronic components units used in automobiles ([IBEF 2017](#)). The actors within the clusters and the networks they form with each other and with foreign companies essentially enable the creation of an open system of innovation that facilitates the emergence of new ideas and innovation within the industry clusters.

5.5. Innovative Corporate Culture

The government plays an important role in any national innovation system in creating a favorable business environment and institutional framework to support R&D in industry and academic institutions. In the automotive industry, the Indian government’s liberalization policies were holistic in the sense that it was driven from the top to ensure collaborations and indigenized R&D efforts by assimilating foreign technology by local players. For example, Mahindra collaborates with Willys to manufacture passenger vehicles, and Bajaj collaborates with Tempo to manufacture a series of three-wheeler vehicles. There are also various technical collaborations of Tata Motors, Ashok Motors, and Hindustan Motors with Mercedes Benz, Leyland Motors, and General Motors, respectively, to manufacture medium and heavy commercial vehicles.

Such a holistic approach in policy formulation and implementation also encouraged indigenized design and development activities. For instance, the two leading Indian auto MNCs, Mahindra and Tata Motors, formed collaborative partnerships with both local and global partners in the product design, trial productions, and the manufacturing of Mahindra ‘Scorpio’ and Tata ‘Indica’. Suppliers were encouraged to come up with their

innovations through design changes and value engineering (Saripalle 2012; Madhavan 2014). This highlights the innovative culture in the Indian auto firms supporting the strong emergence of new product innovations. Besides, with over 20 foreign auto manufacturers located in the five automotive clusters in India, they create symbiotic networks between suppliers, manufacturers and supporting industries to manufacture and market their products (Okada and Siddharthan 2008). The network collaborations between local and foreign auto MNCs in the clusters facilitate the exchange of knowledge and R&D and creates an open system of innovation.

The government has also increased the budget for the National Automotive Testing and R&D Infrastructure Project (NATRiP) in the National Capital Region (NCR) cluster, to open global test centers to develop global competencies in the Indian auto industry (Saboo 2017). The development of such innovation hubs, including the Passive Safety Lab and the Electromagnetic Compatibility Lab, creates a more open innovation system, facilitating networks of knowledge transfer between local firms and multinational firms. It also facilitates the emergence of new product innovation ideas by fostering R&D in automotive safety as well as emission and performance standards. For example, NBC Bearings, one of the major manufacturers and exporters of bearings, has established a dedicated R&D arm in the NCR auto cluster region to conduct research on product design, testing, lubrication, and virtual simulation. In essence, the actors and networks within and between automotive industry clusters, foster innovation in the development and growth of India’s overall national innovation.

The Indian government’s holistic approach in establishing automotive clusters in the five regions promotes the development of human capital and the availability of professional labor. Infrastructure within and between clusters has improved significantly in recent years with the government also pushing for private–public sector collaboration and providing support for funding, commercialization, and developing innovative corporate culture (Jackson et al. 2017). Networks between actors, i.e., local firms, MNCs, suppliers and supporting industries, produce innovative products for the local and international markets through the creation of an open system. The five institutional pillars of how the Indian automotive clusters are structured for innovation are depicted in Table 5.

Table 5. The systems perspective of India’s automotive clusters.

Aspects of Innovation System	Holism	Emergence	Open Systems
Human capital and availability of professional labor	- Skill development government commitment (+)		
	- Establishment of ITIs (+)	- Higher degree of collaboration among various auto industry administrative bodies (+)	- Collaborations among auto MNCs and ITIs (+)
	- Poor primary education in public schools compared to private schools (–)	- Absence of directly comparable degrees in higher education in terms of quality (–)	
	- Lack of incentives, less attractive remuneration in research and education (–)		
	- Shortage of skilled and educated teaching staff (–)		

Table 5. Cont.

Aspects of Innovation System	Holism	Emergence	Open Systems
Infrastructure	<ul style="list-style-type: none"> - Improved intellectual property protection (+) - Increased innovation commercialization (+) - Investment in transport infrastructure, auto clusters, small-scale industries (+) - Weak transparency and anti-corruption laws (-) - Red-tape in starting business, enforcing contract (-) - Poor roads, railways, ports infrastructure, power availability and quality (-) - Complex tax structure (-) 	<ul style="list-style-type: none"> - Focus on multiple-industry sectors along with auto industry for emergence of new product innovations (+) - Overreliance on IT industry, limiting investment in others (-) 	<ul style="list-style-type: none"> - Innovation happens in auto clusters (+) - Collaborations among foreign and local auto MNCs, and policymakers through various organizations such as SIAM and ACMA (+) - Increased competition from foreign auto-component firms because of tax reduction (-)
Private-public sector collaboration	<ul style="list-style-type: none"> - Favorable policy environment to attract foreign MNCs to establish manufacturing, R&D and design centers in India, support auto industry development (+) - Focused government initiatives to promote collaboration such as 'PPP' and 'Skill India' (+) - Procedural rigidity for collaborations leads to a lack of enthusiasm to partnerships (-) 	<ul style="list-style-type: none"> - Joint product development between industry and universities, industrial training institutes (+) - Lack of co-ordination among public institutions and private academic institutions that are organized outside the university system (-) 	<ul style="list-style-type: none"> - Collaboration of auto firms with academic institutions, vocational training institutions to exchange knowledge under various government initiatives (+) - Inefficient and ineffective management practices with high level of bureaucracy (-)
Support for funding and commercialization	<ul style="list-style-type: none"> - Various government initiatives such as NATRiP, Automotive Mission plan and ARAI (+) - A small number of employees in government led research organizations are truly engaged in R&D activities other than providing technical, administrative support (-) 	<ul style="list-style-type: none"> - Financial incentives for R&D (+) - Engagement of local auto MNCs with technology leaders (+) - Investment in R&D by technology leaders (+) - Majority of public academic institutions exclusively rely on government funding (-) 	<ul style="list-style-type: none"> - Government policy allowing 100% FDI in the auto industry (+) - More than 30 R&D centers in India by foreign MNCs (+) - Bureaucratic and procedural hurdles in fund allocation (-)

Table 5. Cont.

Aspects of Innovation System	Holism	Emergence	Open Systems
Innovative corporate culture	<ul style="list-style-type: none"> - Development of multiple auto clusters (auto innovation hubs) (+) - Various government initiatives to create an innovation ecosystem (+) - Still lacking innovation hubs combining academics, professionals, researchers, industry, product development and service sectors (–) - Lack of modern facilities in academic and research institutions (–) 	<ul style="list-style-type: none"> - Collaborations of local auto MNCs with foreign auto MNCs (+) - Risk aversion and follower mentality in some firms (–) 	<ul style="list-style-type: none"> - High-levels of collaboration between firms (+) - Government policies to promote innovation by establishing R&D and test centers (+) - Dominant presence of local, large conglomerates with in-house facilities but often do not engage in external collaborative technology projects (–)

6. Conclusions

This paper explores industry cluster innovation from a systems perspective, by examining Russia’s pharmaceutical clusters and India’s automotive clusters according to the systems concepts of holism, emergence, and open systems. Using the systems concepts, we examine the actors and networks within and between clusters. As clusters are embedded within the boundary of a country’s national innovation ecosystem (NIE), we also consider the institutional pillars of the NIE in terms of human capital investment and the availability of professional labor, infrastructure, private–public sector collaboration, support for funding and commercialization, as well as innovative corporate culture, when examining the development and growth of industry clusters within the national innovation ecosystems.

Our paper provides three major contributions. First, this paper contributes to examining industry cluster innovation through the application of systems concepts (Jackson 2003, 2006). By examining the pharmaceutical clusters in Russia and the automotive clusters in India, we provide insights into how these clusters are structured and managed to facilitate innovation. In the context of Russia’s pharmaceutical clusters, the concept of holism has been illustrated in terms of the history of a strong education system in science, embedded in this industry. For emergence, the government has introduced new higher degree disciplines for aspiring students to encourage innovative ideas from the grassroots. The government has also increased collaborations between industry and academia as well as with foreign multinationals, fostering an open system of pharmaceutical clusters. In the case of India’s automotive clusters, the government is committed to skill development through various initiatives such as the training institutes to support the automotive industry. The concept of emergence is illustrated in the engagement of automotive companies working together within and between the clusters. The collaborations among foreign automotive companies and local companies further foster an open system of innovation, spurring the growth of India’s automotive industry.

The second contribution relates to the application of the systems concepts using a framework of analyzing actors, networks, and the institutional pillars of an ecosystem. In the context of Russia’s pharmaceutical clusters, various actors and their networks within and between the clusters are illustrated. The institutional pillars of an ecosystem are elaborated in terms of human capital development in the pharmaceutical sector, its infrastructure in terms of a large amount of investment in chemical and pharmaceutical research, the continuous private–public sector collaboration, particularly with the government attracting foreign pharmaceutical multinationals, the support for funding and commercialization

with the government investing an average of 3.6% of the country's GDP to foster the growth of the industry, and the development of multiple pharmaceutical clusters to create an innovative corporate culture. The players within India's automotive industry and their networks have also been illustrated in the case study. Similarly, the institutional pillars of the ecosystem have been highlighted to demonstrate how the industry has grown over the past years. The government encourages collaborations among foreign automotive companies and the training institutions to develop its human capital. In terms of infrastructure, strong government policy supports huge investment in transport infrastructure, linking the automotive clusters. A favorable policy environment has also been enacted to encourage private and public sector collaboration. Various government initiatives have been made available to support the commercialization of new products. Finally, the development of multiple automotive clusters (auto innovation hubs) creates an innovative corporate culture, further fueling the growth of India's automotive industry.

Third, we contribute to understanding industry cluster innovation from emerging economies which has not been extensively examined in prior literature. In both cases, the industry clusters facilitate the national innovation ecosystem of the respective country. In the case of Russia, the pharmaceutical industry sector is critical to the development of Russia. Similarly, the automotive industry sector is one of the key sectors supporting India's economic growth. Examining the pharmaceutical clusters and automotive clusters in Russia and India respectively provides insights for research examining industry clusters in emerging economies.

Our illustrations of both Russia's and India's industry clusters have been provided but the analysis is primarily focused on the positive aspects within the systems. The purpose of highlighting these is to illustrate, what and how these countries' governments ensure that they can compete with other countries on a global scale. The systems perspective however highlights that there are aspects within the systems that can be improved. For example, there are still restrictions in terms of trade and investment opportunities in Russia, including in the pharmaceutical industry, and this consequently limits the openness of the system. At the same time, the various levels of red tape limit the holistic nature of change. Moreover, in terms of innovative corporate culture, there is still a sense of distrust, risk aversion, and follower mentality, which limits holism. Leading pharmaceutical companies also tend to look outside of the country for expansion, consequently limiting the strong emergence of new product innovation. The various negative aspects of the systems perspective of Russia's pharmaceutical clusters are depicted in Table 4.

Similarly, when examining India's automotive industry clusters, the benefits may not be as concrete as expected. The Indian business environment is characterized by considerable red tape in starting a business, the lack of transparency due to its weak anti-corruption laws, and the difficulty in enforcing a contract (World Bank 2009). This potentially limits the holistic and emergence view of the innovation system that requires constant interactions between various agencies within the innovation system. The ease of entry of foreign automotive component firms operating in the clusters also increases competition between the actors. In terms of private–public sector collaboration, ineffective management practices with high-level bureaucracy and procedural rigidity are prevalent. Moreover, in terms of innovative corporate culture, there are still limited innovation hubs and modern facilities to foster a holistic approach to innovation. Many Indian firms are also naturally risk-averse and tend to adopt a 'follower mentality'. Thus, they prefer to purchase proven technology rather than spending on R&D (Deloitte 2014). This may limit the emergence of potentially breakthrough product innovations. Besides, large conglomerates within those clusters are also at times hesitant to engage in external collaborative technology projects, limiting the openness of the system. Table 5 further details the negative aspects of the systems perspective of India's automotive clusters.

The arguments presented in this paper have implications for managerial practice. For policymakers, it is important to analyze the formulation and implementation of new policies from a systems perspective as consequences of these policies will be multi-level.

For organizations operating in these clusters, it is fundamentally critical to view the actors and the networks within and between the clusters they are operating in. Operating out of these clusters also brings additional benefits, but it could also constrain the growth and development of organizations within clusters. As such, a systems view of holism, emergence, and openness needs to be considered to understand the coherence of such ecosystems (Suseno and Standing 2018). In addition, a systems perspective of industry clusters from emerging economies provides important implications for managers and policymakers to consider both the positive and negative aspects to build an innovation ecosystem to promote more effective industry cluster innovation. The institutional pillars of NIE are important to be considered and applied to industry cluster innovation as clusters stimulate innovation and economic growth.

There are important limitations to this paper. First, the paper does not provide empirical primary research data on industry cluster innovation. Second, the focus of the study on examining industry cluster innovation is primarily positive in both the pharmaceutical clusters in Russia and the automotive clusters in India. However, we acknowledge that there are limitations or negative aspects concerning the institutional pillars when examining industry cluster innovation, which we have briefly noted in Tables 4 and 5, respectively. Future research can further examine the negative implications of the systems concepts of holism, emergence, and openness, particularly in the context of emerging economies, to foster industry cluster innovation and promote a more effective national innovation ecosystem.

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