Incubation and development: an overview of technology incubation innovation system of India

Kanchan Lala and Kunal Sinha
Center for Studies in Science, Technology and Innovation Policy, Central University of Gujarat, Gandhinagar, India

Abstract

Purpose – The purpose of this paper is to analyze and summarize growth and development of technology business incubation system in India. The study in this route tries to explore factors which include various actors and agencies influencing the process of incubation and innovation.

Design/methodology/approach – The paper in route to access the role of different actors and agencies situated around the incubation process is being executed through the systems of innovation framework. Data have been collected from the secondary sources including government department, ministries and other sources.

Findings – The study besides providing an in-depth analysis of the incubation process in India finds that the process is relatively new in the Indian context and lacks a profound policy for escalating the process of technological incubation. The study also finds that over the years India's innovation potential has escalated significantly which in a way can be seen as an optimistic result in the growth and development of technology business incubation.

Originality/value – The proposed study is one of the few in this category, especially while analyzing technology business incubation with respect to India. The study also tries to add on literature in the domain of technology incubation especially in the context of India.

Keywords India, Technology business incubation, Innovation, Incubation, Start-ups, National innovation system

Paper type General review

1. Introduction

The basic objective of innovation from its definition to commercialize invention, which includes the process of a new product, process or new organizational form, is deeply rooted in helping human being live a comfortable life. Technology business incubation is one such arrangement where the start-ups explore their ideas into visionary dreams under a guided support by the incubator (Phillips, 2004).

The process which was initiated accidentally from Batavia industrial center in New York around 1959 has now be seen at almost all the corner of the world. The model besides creating low-cost and effective innovation also adds on other aspects ranging from job creation, enhancing technological capability and even helping in better academia-industry collaboration (see Table I).

However, besides similar in structure, the concept of innovation is significantly diverse at different locations, for developing countries it is more of a radical in nature or radical innovation whereas for the developing countries the structure is more of incremental or import based. To dilute these two poles technology-based incubation program act as a blend between the two, by promoting low-cost innovation in the diversified areas ranging from healthcare, biotechnology, automation to robotics (Manimala and Vijay, 2012).

In India, the process of technology incubation took shape in 1982 with the setup of National Science and Technology Entrepreneurship Board (NSTEDB) an apex body under the department of science and technology in 1982, with a broader objective to enhance technological growth by integrating academia-industry for an effective, efficient and sustainable development (Tang *et al.*, 2013). In India, there are 125 technology business incubators (TBIs) located at various locations, having research domain in every diversified

World Journal of Science, Technology and Sustainable Development
Vol. 15 No. 3, 2018
pp. 226-244

2042-5945
DOI 10.1108/WJSTSD-01-2018-0001

and emerging areas of science and technology. The data in Table II provide a comprehensive overview of India's incubation process.

The central purpose of this paper is to provide an overview of the technology incubation process in India. The paper is being organized in the following pattern. The next section elaborates the literature in the domain of TBI with special reference to India, followed by Section 3 describing the analytical framework. Section 4 introduces the methods. Section 5 discusses the technology incubation system in India. The final section concludes with remarks and future implications.

2. Review of literature

Innovation is regarded as one of the important aspects in the life of every individual across the globe; the concept which emerges with the early work of Schumpeter (1934) can now be traced in the national policy of every nation throughout the globe. Besides the difference in approach by developed and developing nation, the concept has created a new trajectory in the economic development. Research on innovation suggests that innovation is a systematic phenomenon, where the interaction and interdependency between various actors and agencies shape the entire innovation process.

With the shift in the structure of the universities from teaching and research to entrepreneurial mode, universities have become a significant player in spearheading the mechanism of innovation and development (Wissema, 2009; Mowery and Sampat, 2004). The process which involves generation, transfer and diffusion of knowledge through technology transfer, patenting and commercialization of innovation is shaped by the integration and interdependence between various actors, institutions and policymakers.

The term "technology business incubation" (university entrepreneurship, techno-entrepreneurship, academic entrepreneurship, incubates, start-ups) is often being referred in the academic literature to describe the way universities have undergone interaction with the

Actors and agencies	Benefits
Government	Job creation, national and regional development, increase in technology capability
R&D	Helps in commercializing technology or invention, improves interactions with industry
Business and corporate sectors	Better choice for investment, access to new technology
Start-ups	Access to resources and business support, reduces initial market risk

Source: United Nations Publication (2004)

Table I. The benefits of incubation process of various actors and agencies

Location	More than 60 percent of the incubators are located in the urban locations
Host institute	Around 45 percent of the host institutes are from the public sector and 55 percent from the private sector
	over 75 percent of operation is done from academic institute, 7 percent from R&D institute, and 6 percent from Science or IT Park
Focus sector	Around 30 percent-ICT/Electronics
	20 percent on Health/Biotechnology
	13 percent on Agriculture
	14 percent on Nanotechnology, Textile, Media
Business Model	87 percent on "not for profit"
Legal Structure	68 percent registered under society Act
	19 percent a part of host Institute

Source: Data from NSTEDB database (www.nstedb.com)

Table II. Overview of incubation process in India

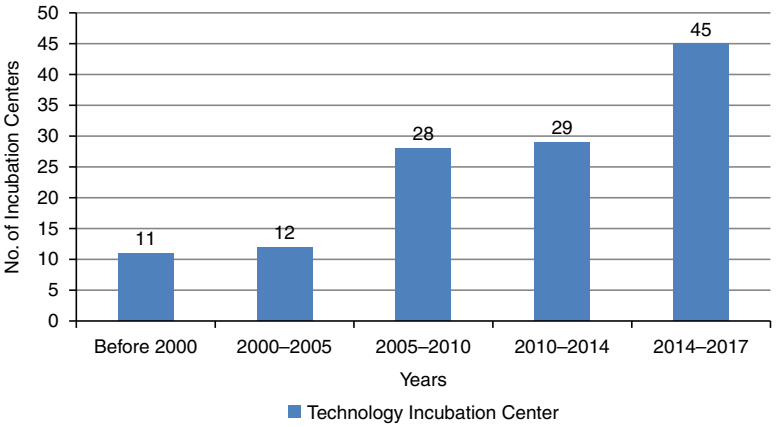
industry or market. In this context, a growing body of academic literature related to academic entrepreneurship based on the national, regional and sectoral development has been addressed and many others have come out for further attention.

Technological entrepreneurship/incubation or techno-starter is one such step which enables the promotion of knowledge from the lab to the market, apart from this the effective environment of the academic spin-off, technology transfer and intellectual property rights mechanism has facilitated a new framework in the university system by integrating university, government and industry (Lundvall, 1992). However, according to Mowery and Sampat (2004) universities is being regarded as an important and essential component in the knowledge economy. Further, apart from producing and distributing knowledge, universities act as a key factor in producing "knowledge worker" or knowledge workforce. On the broader note, the process of incubation not only helps in developing new and competitive products in the market by promoting entrepreneur from the spin-off process but also helps in developing the knowledge discourse and technological capabilities (Al-Mubaraki *et al.*, 2015).

The technology developed by these incubatees not only promotes the entrepreneurial environment in the country but also creates jobs, along with enhancing the technological base of the country. Techno-starter or Technological entrepreneur in these incubation centers mainly consists of students or faculties, who establish their own firm based on technology. The incubatees often originate from university spin-off. The spin-off is being defined as the firms which emerged from academic institutes, through transfer and commercialization of knowledge produced in the university periphery (Chandra and Krishna, 2009). In other words, techno-starter or start-ups act as a balance between demand-supply and technology market, in other words, the conversion of ideas into a product not only improves the technology but also helps in measuring the market scenario. However, the generation of ideas are common phenomena, but the effectiveness of the same is measured only when it turns out in the market.

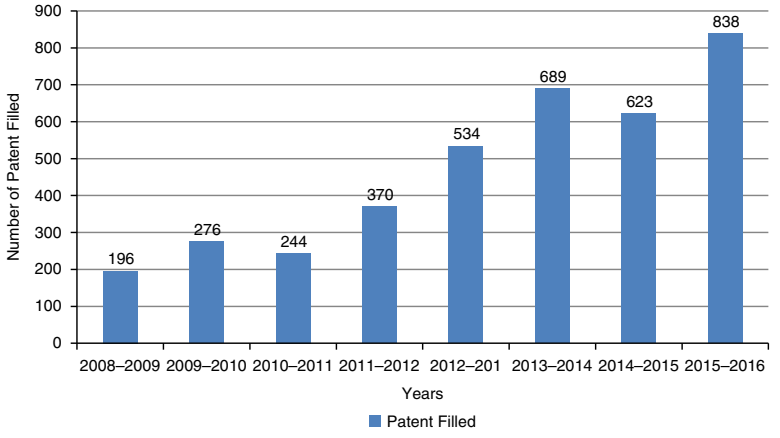
On the other hand, the emergence and evolution of incubation model have had a completely different experience in both the developing and developed countries. Technically sound infrastructure and favorable policies namely the Bayh–Dole Act[1] (1980) in the USA and the Torch Program[2] in China have consolidated the incubation process (Manimala, 1997; Tang *et al.*, 2011). Though India had started its incubation program in the same era as of China the lack of concrete planning and exclusive policy from the governments to encourage technology transfer and effective academia-industry collaboration has declined its escalation (Lala, 2016). Besides these, the process of incubation in India is on a progressive note with the establishment of new incubators across different locations in the country. The data shown in Figure 1 suggest an increasing trend since 2005 in the growth of technology incubation center.

Knowledge production is one of the key aspects in the academic ecosystem, with the shift in the role of the university from research base to market-oriented R&D has initiated a new discourse in the academic ecosystem (Wissema, 2009). With this shift the knowledge production and transfer mode through patent filling have shown a significant rise, the data projected in Figure 2 show a similar trend. The data show that over the years the patent filling in the Indian universities (which includes both private and public, technical and non-technical) has increased at a growing rate of 400 percent since 2008 to 2015–2016. The reason for an increasing trend is due to various amendments in the patent act, along with the introduction of various plan and schemes over the years (Table IV). The figure on patenting trends (Figure 2) seems relevant besides projecting the innovative potential is that in India with the lack of technology transfer offices (TTOs) the commercialization research from the university is mostly done through these incubation centers. The incubation centers through various schemes promote spin off process, which in a way has escalated an increasing trend in both the number of incubators and the patenting trends over the years.



Notes: Presently the total number of incubator in India is 125; the data projected in the graph have not included newly established TBI as they are in the birth stage
Source: Authors' own compilation from NSTEDB database (www.nstedb.com)

Figure 1. Growth of TBI in India



Source: Authors own compilation from various annual reports of CGPTDM

Figure 2. Growth of patent filled by Indian university/institute at Indian patent office

The literature on technology business incubation provides mixed views, on one side it promotes the advantages of commercializing technologies (Phillips, 2004) by providing an effective an efficient way for transferring technologies, generating revenues and also job creation (Aernoudt, 2004). But on the other side, the conflict of interest in holding the technology ownership between the university and incubatees (Phillips, 2004) and also a long transfer mechanism has added difficulties for an efficient incubation process (Eisenhardt and Martin, 2000).

Over the years the research on incubation and also its model has changed significantly. Earlier studies on incubation were focused more on understanding the concepts in fragmented dimensions namely: physical facilities, rent, logistics and management support and many more. But with the change in the way incubators support to the start-ups from mere facilitating infrastructure to more of facilitating network has reshaped the mode of

inquiry in the literature on technology business incubation (Bruneel *et al.*, 2012; Matt and Tang, 2010). Over the years, network-based incubation has drawn considerable attention in the incubation literature, as the previous theories have contributed marginally and had a fragmented approach in analyzing the incubation literature. It has been found that literature on technology incubation is mainly guided by three management theories, namely, resource-based view, knowledge-based view, organizational learning, and social capital theory, which has tried to address the issue related to incubation in quite a fragmented way. The resource-based theory explores the resources and capabilities by which the product and services can be developed, whereas according to knowledge-based or organizational learning theory is more inclined toward knowledge and learning. On the other hand, social capital theory through relationship and ties will escalate the incubation process. Besides these approaches the research on incubation has failed to deal with the issue of performance of the start-ups and less attention has been paid in understanding the process of the incubation (Eveleens *et al.*, 2017). However, on the other hand, the study by Kimatu (2016) suggest to put in the role of civil society in the triple helix model of academia-industry and government to build up an inclusive incubation model for the common people. However, according to Bulsara *et al.* (2009) in his paper suggests that the technology innovation at the incubation centers is a broad concept and research in this area is not concentrated merely on technology but more precisely on the interaction and learning that modifies or accelerates the entire process.

Network of various actors and agencies plays a significant role in transforming innovation, Arnold and Quelch (1998) in his study finds that in developing countries the process of incubation which includes product development, patenting, marketing, funding and commercialization are not synchronous to each other and are mostly mutually exclusive and fragmented component which in a way constrict the performance of the incubator or incubatees. On the other hand, it has also been found in the academic literature that apart from these hindrances and problems, intellectual property rights plays a significant role in promoting innovation. Mainly on new ventures mainly the start-ups according to the scholar like Mazzoleni and Nelson (1998) patenting for early-stage technology developed at university incubation center offers quite a diverse representation in the context of validating IPR regulations. Acquiring a patent at an early stage before commercializing the product assures that, if the technology is being developed successfully, its economic reward is inevitable. In other words, patenting to these early-stage incubates motivates apart from motivating, also provides a platform where they can negotiate financially and technological collaboration with different financial and technological institutes.

In this context, the study by Chandra *et al.* (2007) comes across with the finding that the problems in figuring the productivity with respect to innovation in these incubation centers are not affected due to technology or R&D, but with a tough task to integrate these mutually exclusive components namely: seed funding, technology transfer, commercialization, R&D, marketing, IPR elements within a limited time frame. Moreover, policies have a huge impact on the promotion of entrepreneurial activity in the country, according to the study by Etzkowitz (2002) and by Sikka (1997) on Indian context, it has been found that unawareness among the start-ups regarding various plans and program has limited the entrepreneurial ecosystem. Although the initiative to promote an effective and efficient innovation system through the establishment of technology business incubation program started in the early 1980s but it still lacks an efficient and effective mechanism in the present context. While undergoing literature on the same theme very limited and fragmented research is being traced.

2.1 Studies on Indian context

The initial study by Manimala and Vijay (2012) and the work of Tang *et al.* (2013) has tried to provide a glimpse to the incubation process by concentrating mainly on the

infrastructural theme like its configuration, the facilities provided by incubators with a little emphasis on innovation theme. On the other hand, the study by Chandra *et al.* (2007), Basant (2011) and Sonne (2012) traces the problem in converting techno-innovation to techno-entrepreneur due to administrative and financial problems, respectively.

However, the study by Krishna (1991) observed the changing dynamics in the knowledge production and dissemination in India, the study located around Indian Institute of Technology (IIT) tracks the formation of incubation center to develop new technology through the spin-off. Further, the instruments of IPR and patenting is being used to commercialize the knowledge production in the domain of knowledge economy (Chandra and Krishna, 2009). In other words, it has been observed that with changing dimensions of university structure around the world, the university structure in India has also moved toward an entrepreneurial structure, by adopting instruments of incubation, spin-off, technology transfer and IPR.

In addition to these, the study by Ojha (2009) highlights the role of social, economic and political aspects in constraining the incubation process in the country. According to him besides the under-developed financial markets, time-consuming bureaucratic procedures of the bank and other legal institutions, lack social support from family and friends to undergo entrepreneur as a career is one of the major problems in promoting incubation program in India. In addition to it all these literature, only the study by Tang *et al.* (2013) provides a comprehensive glimpses and a comprehensive analysis of technological incubation process in India, the study apart from evaluating India's incubation process through the framework of national system of innovation (NSI) also adds a detailed comparison between China and India. In conclusion, it is has been found in the literature review mainly in the Indian context that that the problem adjoining for implementing an effective innovation platform especially in the context of India is numerous, starting from administrative hurdle to law and regulation, IPR policy, apart from commercialization and diffusion of new idea in the market.

However, from the research point of view, it has been found that the lack of literature and fragmented research on themes like funding, infrastructure, legal (IPR), social and economic has fondled the research on technology-based incubation program mainly on the Indian context partially. So with the objective to provide an overview of technology incubation by situating actors and agencies finds the relevance of research on the said theme. In other words, apart from these scholar's contribution, there has been no further study in relation to analyzing the interaction and linkages between different actors and institutions underlying the innovation process. India as one of the emerging and fastest developing economies in the world has experienced quite a mixed fortune in the current economic growth. On the positive side with greater flow of inwards and outward foreign direct investments (FDI), with a significant position in exporting computers and information services and along with the evolution of "frugal innovation" in the world, while on the other side with growing inequalities in the income ratio, along with sluggish job creation adds complexities to its economic growth chart (Mani, 2015). In other words, the current complex situations promote the emphasis on incubation process a key component to addressing the above issues.

3. Analytical framework

The process of innovation is a systematic phenomenon, where various actors and agencies associate together by interacting and following interdependency among them for building an effective innovation system. The concept of systems of innovation (SI) rests on the objective that innovation in firms is not an independent phenomenon rather it is the interaction and interdependence between different elements or components in the system. The interaction and interdependence have a huge impact on the innovation process. The concept which was developed parallel in Europe and the USA around 1980s, by

Christopher Freeman in collaboration with IKE group. The collaboration helps in developing the early concepts in developing SI approach. The early work of Freeman conceptualized the system approach in order to understand the process, historical insight and collaboration, was later developed by the work of Lundvall (1992), Nelson (1993) and Edquist (1997) in defining and theorizing the concept more holistically.

The concept of National Systems of Innovation (NSI) or commonly termed as NSI was developed in 1980s. The framework centered on country-specific factors influencing the process of innovation. The concept is mainly linked with three authors: Freeman (1987), Lundvall (1992) and Nelson (1993). The NSI framework gives a holistic approach to the interaction between actors involved in the innovation process. The concept rests on three important words "National, System and Innovation" which gives the fundamental concept to the NSI framework. Thus, with the broader objective of sketching the innovation trajectory of India, the study has chosen the framework of an NSI for mapping linkages between different actors and agencies involved in the technology incubation–innovation system.

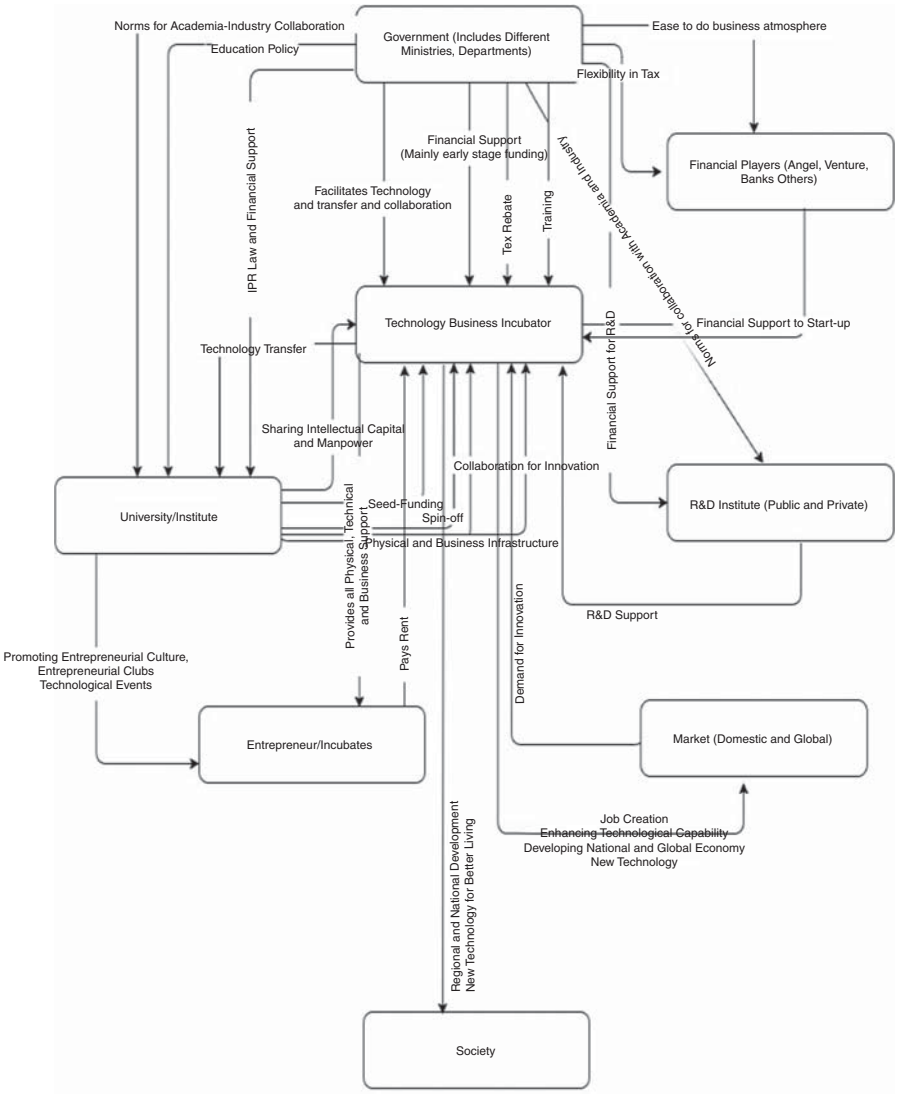
Moreover, a novel schematic diagram including various actors and agencies involved in the technology incubation process has been projected (see Figure 3). Further, the paper explores all the key dimensions projected by NIS, namely, entrepreneurial structure, R&D activities, various government policies related to technology incubation and funding opportunities for the incubates or start-ups in projecting the dynamics of innovation at the technology incubation center.

4. Methods

The debatable question for the scholars and policymakers in the developing countries like India is, whether the process of incubation can trigger off technological development in the country, besides elevating revenue and jobs? However, as mentioned in the pieces of literature, there has been limited information about the innovation at incubation centers, as most of the scholarly contribution like that of Manimala and Vijay (2012) and the work Tang *et al.* (2013) which provides an initial glimpse to the incubation process in India mainly only its configuration, facilities provided, by partially addresses the domain of innovation.

In addition to it, only the study by Tang *et al.* (2013) provides a comprehensive analysis of technological incubation process in India, by analyzing it through the platform of the NSI. The study reveals the importance of NSI is analyzing the similarities and differences in the incubation process between two emerging economies.

In other words, apart from these scholar's contribution, there has been no further study in relation to analyzing the interaction and linkages between different actors and institutions underlying the innovation process. India as one of the emerging and fastest developing economies in the world has experienced quite a mixed fortune in the current economic growth. On the positive side with greater flow of inwards and outward FDI, with a significant position in exporting computers and information services and along with the evolution of "frugal innovation" in the world, while on the other side with growing inequalities in the income ratio, along with sluggish job creation adds complexities to its economic growth chart (Mani, 2015). In other words, the current complex situations promote the emphasis on incubation process a key component to addressing the above issues. The process as reviewed in the literature apart from escalating the technological capability, it also promotes jobs (Manimala and Vijay, 2012). Given the importance of technological development and enhancing jobs and revenue for the country, the research on incubation process deserve more attention, especially with the broader research areas by the incubates ranging from IT & Electronics, Biotechnology, Healthcare and other disciplines of engineering domain. The present study, which provides an overview of incubation process, is expected to contribute larger measure toward the understanding of technological business incubation process in India. The study besides addressing the components of



Source: Lala (2016)

Figure 3.
Schematic diagram of innovation system at TBI

system approach also looks toward various policy and regulation in relation to start-ups. The significance of the present study also lies in the fact that as it tries to identify and prioritize the relevant areas where government intervention is needed.

The reviews of literature illustrate the importance of interactions and linkages between various actors and agencies within the domain of innovation. The activities at TBI in an innovation system is being influenced by the interaction of a large number of actors mainly government and various institutions. The study aims to map out the interactions and linkages in the context to analyze the innovation process at these incubation centers. The paper stressed that the study of these linkages and interactions are quite significant in

understanding the dynamics of knowledge production and transfer phenomenon. In other words, the study in route takes the system approach to evaluating the degree of innovation within the chosen field of study. The precise question in this study is to track the linkages at the TBI, with an in-depth analysis of collaboration between different actors and agencies, including both technical and non-technical interactions within the system. The study was carried out through secondary literature consisting of various annual reports, academic literature including working and journal papers for mapping the incubation-innovation system. Moreover, from the methodological view, the main aim of the study is to understand various activities or behavior occurring in the vicinity of the TBI.

Furthermore, the study wraps different S&T technology policies introduced by the government. These policies parameters are effective in analyzing the growth of S&T are figured as "Horizontal" whereas the policies specific to the TBI and start-ups and termed as "Vertical". The study includes in-depth analysis of interactions between different actors and agencies in the discipline of S&T, with respect to TBI. The paper has listed some incubators both from the public and the private institutions to elaborate the process of technological incubation. The guided rational behind the selection of these randomly chosen institutions comprises of various indicators and heterogeneous attributes such as active engagement in knowledge production (Patenting), broad areas of R&D at the incubation center. In other words, the chosen institutes provide a glimpse of the core functions in India's innovation system mainly in the context of technology business incubation

5. Technological incubation in India

Technological incubation is being one of the foremost projects in promoting innovation and entrepreneurship in the domain of the third generation university system. In India, the incubation program is promoted through NSTEDB under the Department of Science & Technology (DST). The process which started in 1984 is more than three decades old, but with the Stumbling block in the early-stage finance, together with the administrative hurdles, and low acceptability in the market adds peril to its success. However, a typical incubation process consists of three phases:

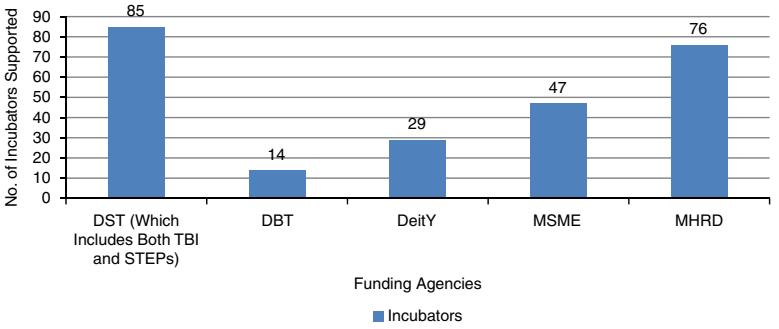
(1) birth phase or pre-incubation process;

(2) survival phase; and

(3) growth phase.

The phase which starts through the spin-off procedure, needs an guided physical legal, management and financial support for commercializing the prototype from lab to the market in the survival phase until in the graduation phase where these budding companies have to compete in the market (Marda, 2015). However, with the steady increase in the number of incubators (see Figure 1) in the coming years, followed by a remarkable patenting trend by the Indian institution (see Figure 2) justifies the increasing trends in the incubation process.

More particularly the patenting figure shows a 400 percent increase in the patenting trend since 2008–2009, the reasons for the increasing trends are due to various favorable policies in the domain of technology-based incubation (Table IV). Moreover, besides these increasing trends, it has been found that the government agencies are the main contributor in the incubation process. The data projected in Figure 4 puts forward the financial support to respective incubators by different ministries and department. The data also highlight that DST and Ministry of Human Resource and Development (MHRD) are being one of the major funding agency in promoting the incubation process. Whereas the presence of sector-specific funding from the department of Department of Electronics and Information Technology (DeitY) and Department of Biotechnology (DBT) adds more diversity in the domain of innovation in this process.

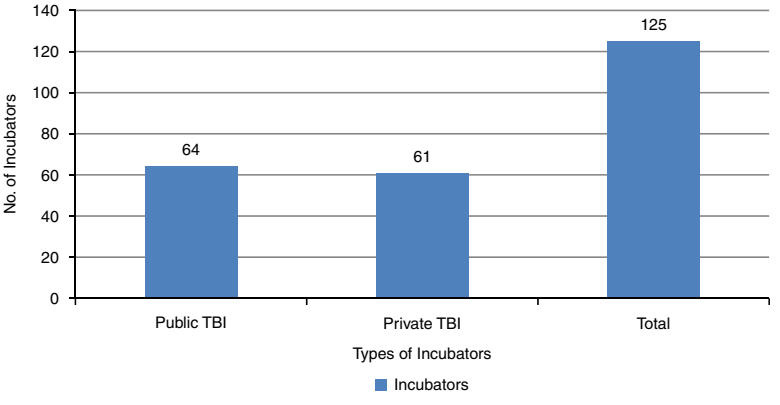


Notes: The numbers of incubators shown in Figure 4 are multifunded by various ministries and government departments. The data shown in the figure cannot be summarized in total as an individual unit. Abbreviation used in the Department of Biotechnology (DBT); Department of Science and Technology (DST); Department of Electronics and Information Technology (DeitY); Ministry of Micro, Small and Medium Enterprises (MSME), Ministry of Human Resource and Development (MHRD)

Source: authors own compilation from Ministry of Commerce and Industry database: http://startupindia.gov.in accessed March 1, 2017

Figure 4.
Numbers of Incubators Supported by Various Ministries and Department

However, besides the support from the government agencies, venture capitalist funds both from the national and foreign agencies (Table VII) also provides support for escalating the incubation process in the country. However, as mentioned in the literature review innovation is an interrelated process where the active engagements of various actors and agencies transform an efficient and effective innovation ecosystem. Entrepreneurs or entrepreneurial activities are the key drivers in an innovation system, with a propensity to enhance new technology has transformed the innovation ecosystem (Hekkert *et al.*, 2007). In India, the presence of such active engagement can be traced while evaluating the list of incubators involved from both public and private institutions. The data shown in Figure 5 show an equal participation of both public and privately affiliated institutions. The data validate the fact that the activity of



Source: Authors' own compilation from Ministry of Commerce and Industry database: http://startupindia.gov.in (accessed March 1, 2017)

Figure 5.
Portfolio of type of TBIs in India

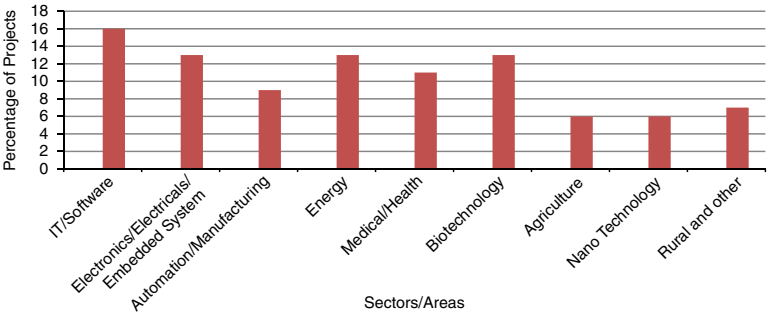
innovation though mainly supported by the government agencies are not confined only to the public institutions rather the process is being equally shared and facilitated in the private institutions in the same way provided with the equal infrastructure guideline (Table III) for promoting an efficient incubation innovation system in the country. While undergoing the portfolio of the technology developed at various incubation centers over the years it has been found that the presence of diversified research in both high technologies and emerging technologies like nanotechnology and biotechnology (Figure 6).

On the broader note, this diversity and active participation of various actors are not influenced only due to the infrastructure and visionary dreams to create something new, but the presence of active technology incubation policies has been the key aspect in this transformation. The list provided in Table IV illustrates various schemes provided to the incubatees for the promotion of incubation process in India. The schemes which range from providing funds for the early-stage fund, i.e. to assist proof of an idea, until the commercialization of product act as a key driver in the incubation process. In addition to this, the sector-specific funding by departments like biotechnology and electronics has provided an additional thrust in the promotion of high technology research namely in the sector like IT, Nano & Biotechnology. The data projected in Table V illustrate the diversified products developed ranging from the green technology to machine and cloud computing by the incubatees.

Promoters	Facilities provided	Services offered
1. Department of Science & Technology (DST)	1. Nursery sheds	1. Testing and calibration
2. IDBI, IFCI, ICICI	2. Testing and calibration facilities	2. Consultancy
3. Concern State Government	3. Precision tool room/central workshop	3. Training
4. Host Institute	4. Prototype development	4. Research
5. Commercial Banks	5. Business facilitation	5. Prototype development/ Process development
	6. Computing	6. Human resource development (short-term courses)
	7. Data Bank	7. Technical support services
	8. Library and documentation	8. Business facilitation services
	9. Communication	9. Database and documentation services
	10. Seminar hall/Conference room	10. Quality assurance services
	11. Common facilities such as telephone, telex, fax, photocopying	11. Common utility services

Sources: Rajan and Jain (2012); United Nations Publication (2004)

Table III.
List of facilities, and services offered by TBIs



Source: Authors' own compilation from NSTEDB database www.nstedb.com

Figure 6.
Portfolio of sector wise projects in all incubators

Schemes	Introduction	Year of establishment	Objective
Technopreneur Promotion Program (TePP)	DST	1998–1999	To promote technology-based entrepreneur
Small Business Innovation Research Initiative (SBIRI)	DBT	2005	To boost public–private partnership for early stage funding
Biotechnology Ignition Grant Scheme (BIG)	DBT	2012	To promote commercialization of ideas by scientists or start-ups
Students Innovations for Advancement of Research Explorations (SITARE)	DBT	2013	To support innovation and creativity at grassroot level among the university students, including individuals
NIDHI Prayas	DST	2016	It assists early stage funding to start-ups, i.e. from idea to proof of concept
Technology Incubation and Development of Entrepreneur (TIDE)	DeitY	2008	It assists the institution/TBI in assisting technology developed by start-ups for commercialization mainly in the area of Electronics, ICT
The New Millennium Indian Technology Leadership Initiative (NMITLI)	CSIR	2003	Development of sustainable and eco-friendly, new technologies/concepts for Indian industries. Through public–private partnership
Promoting Innovations in Individuals, Start-ups and MSME's (PRISM)	DSIR	2014	Support individual innovators which will enable to achieve the agenda of inclusive development
Support for Entrepreneurial and Management Development of SMEs through Incubators	MSME	2005-06	To Promote emerging technological and knowledge-based innovative ventures through incubation process
Atal Innovation Mission	NITI Aayog	2016	Atal Innovation Mission (AIM) including Self-Employment and Talent Utilization (SETU) is Government of India's endeavor to promote a culture of innovation and entrepreneurship

Source: Authors' own compilation from multiple sources official website of Council of Scientific and Industrial Research (CSIR), Department of Scientific and Industrial Research (DSIR), Department of Biotechnology (DBT); Department of Science and Technology (DST); Department of Electronics and Information Technology (DeitY); Ministry of Micro, Small and Medium Enterprises (MSME), The National Institution for Transforming India (NITI Aayog)

Table IV.
List of schemes to support technology business incubation program in India

5.1 Funding landscape

The economic policy of a nation has a huge impact on its entrepreneurial behavior, which in a way results in providing an effective and efficient innovation system (Ojha, 2009). In India, the process of technological entrepreneurship or techno-starter is quite a tough job to execute in the Indian scenario.

However, besides the administrative, technological and market hurdles the problem of early-stage funding has always been a key variable in pulling back these ideas from being a workable one. Although there are quite a handful amount of funding opportunity available ranging from relatives or friends, venture capitalist, angel investors, banks with the risk of failure at early-stage pull back these funding opportunities for the techno-starter. In other words, getting start-ups to grow and that too for a techno-entrepreneur is quite a challenging task, not only because of uncertainty with the technology but also with the long process involved in commercializing the product in the market.

So with the longer procedure, the investor has to wait quite a handful amount of time to visualize the effectiveness of the technology, which makes investor quite skeptical. So an entrepreneur has shifted toward their own funding options to move their firms toward

Name of TBI	Public/ private	Name of the incubatees	Area of research	Contact
STEP IIT KGP	Public	Ants Labs and Ants ceramic	Material Science-Ceramic	http://antslab.co.in
		Ecogen Solutions	Solarpower	www.ecozensolutions.com/
		Sankalp Semiconductor	Semiconductor	http://sankalpsemi.com/
		Zreyas Technologies	IOT	www.zreyastechnology.com/
SIDBI IIT Kanpur	Public	E-Spin Nanotech	Nanotechnology	www.espinnanotech.com/
		Kanopy Techno Solutions	Applied Electrochemistry and Nanotechnology	www.kanopytech.com/
		Curadev	Biotechnology	www.curadev.in/
		Four front analytics	Cloud-based business analytics	http://4frontanalytics.com/
		Aus	GIS	www.aus.co.in/
KIIT TBI	Private	Bionivid	Biotechnology	www.bionivid.com
		Malus Technology	Software aolutions	http://malustechnology.com
		Green Go Auto	Green technology	http://greengoauto.com
		Kanak Bio Science and Research Pvt. Ltd	Agri-Biotechnology	http://kanakbio.com
VIT TBI	Private	Cardiac Design Lab	Healthcare	www.cardiacdesignlabs.com
		Actonate	Cloud computing	http://actonate.com/
		Kraftigo	Software solutions	www.facebook.com/kraftigo
IIT Madras	Public	Swadha Energies	Energy	www.swadhaenergies.com
		Ather Energy	Green technology-electric scooter	www.atherenergy.com/
		Skill Veri	Engg- weilding Technology	http://skillveri.com/
		Invention Labs	Machine learning-speech technology	http://inventionlabs.in/
		Uniphore Software	Machine learning	www.uniphore.com

Source: Authors' own compilation from multiple secondary sources

Table V.
List of successful incubatees from selected technology incubation centers in India

successful company (Ojha, 2009). Besides this, there has been quite a handful funding option available mainly by the government agencies from birth to growth stages of the incubation process. Table VI describes the salient feature of various government schemes for the start-ups, besides these, the table also tries to map out various funding agencies supporting at the various stages of the incubation process.

The funding landscape for the incubation process as tabulated in the table above shows quite a significant projection of funding opportunity for the incubates. Besides the support by government agencies and ministries, there is quite a handful number of venture capitalist both from India and foreign agencies are also providing sufficient amount of funding for the start-ups (Table VII).

Besides the major funding opportunity from the government agencies, the incubatees' share of recurring finds which includes the second installment ratio is quite low even from the government sources. The figure projected in Figure 8 shows the declination of funding opportunity over the year in terms of recurring funds for the techno-starter. The collapse in the funding opportunity has a huge impact on the transformation of incubates from attaining the growth stage in the incubation process.

On the other hand, the data projected in Figure 7 show a huge increase in the funding structure by venture capitalist from both domestic and foreign investors in various sectors over the years. The investment by both the VCF's and FVCF's is showing an increasing

Type of fund	Feature	Major funding agencies
Technology development funds	Funds are meant for early stage financial support to the techno-starter. The fund aimed at supporting early works such as idea development, demonstration of concept, and validation of idea	DSIR, DST, DBT, NRDC
Funds for patent protection and technology in-licensing	The fund is meant to support providing patent protection and in-licensing	DSIR, MoMSME, NIF, MIT, CSIR
Technology scale-up or validation funds	Technology scale-up funding is to scales up and validating activities related to technology/product/process	SIDBI, NRDC, CSIR
Market entry funds	The market entry funds helps the start-ups in performing, variety of marketing and business oriented activities to commercialize the product in the market	MoMSME, DBT, NRDC, KITVEN, SIDBI, DIT, Angel Networks
Expansion funds	The expansion is the last stage of the incubation process, the fund is basically used for escalating the product in the market. In this stage the incubates need massive funds	SIDBI, DIT, DBT, MoMSME, Angel Networks

Notes: CSIR, Council of Scientific & Industrial Research; DIT, Department of Information Technology; DSIR, Department of Science and Industrial Research; DST, Department of Science and Technology; DBT, Department of Bio-technology; KITVEN, Karnataka Information Technology Venture Capital; MIT, Ministry of Information Technology; MoMSME, Ministry of Micro Small Medium Enterprise; NIF, National Innovation Foundation; NRDC: National Research Development Corporation; NSTEDB, National Science and Technology Entrepreneurship Board; and SIDBI: Small Industrial Development Bank of India

Source: Authors' own compilation from various annual reports, government document and website of http://funding.venturecenter.co.in/index.php

Table VI. Overview of funding sources

trend in which the VCF investment has stepped up by nearly 255 percent whereas for the FVCF's the increase is 585 percent. This increase in the amount of investment by the FVCF's is can be traced due to the increasing trend in the knowledge production and amount of increase in the start-ups. Moreover, with the diversified sector of research in both applied and basic research over the year has also contributed a lot in developing the innovation ecosystem of the country. Though with the increase in funding from the venture capitalist has provided a positive support in the start-up ecosystem most of these funding is for the established start-ups rather than for the recently launched (Figure 8).

6. Conclusion

The main objective of the paper was to map the process of incubation by analyzing it through the framework of national innovation system, which mainly focuses on linking various actors and agencies located in the process of incubation. However, the literature review and the in-depth analysis on various aspects of technology business incubation state the important role of institutions, organizations alongside the role of linkages, and interaction between actors in influencing the process of innovation. The paper focuses on the role of networking around TBI as a central actor and how the interactions between technological and non-technological activities, influences the overall incubation process.

The present study shows that though the incubation process in India is quite new as compared to countries like the USA, and China, the process has grown quite significantly. The number of incubators and the diversified domain of innovation R&D at various incubation centers provide a positive trajectory of innovation. Besides a diversified research domain, the patenting trends of Indian universities and institution bring out an efficient and

VCF's			FVCF's	
National level venture capital organizations	State level venture capital organization and others	Asian venture capitalist in India	African venture capitalist in India region	European and others venture capitalist in India
IDBI Venture Fund	GVFL	Steadview capital	Naspers Group	Baillie Gifford
ICICI Venture	APIDC	RB Investments		Kinnevik AB
SIDBI Venture Capital	Uttar Pradesh Venture Capital Fund	Ru-Net Holdings		Sofina
NFSIT	Industrial Venture Capital limited	DST Global		Nokia Growth Partners
IFCI	KITVEN Fund	Temasek Holdings		FTV Capital
CVCF	IVML	Tybourne Capital		General Atlantic
IL&FS	Marigold Capital Management Limited	Maverick Capital		Gray Matters Capital
		BEENEXT		Thrive Capital
		Foxconn Technology Group		Velos Partners
		Vy Capital		BlackRock
		Rebright Partners		SoftBank
		Brother Fortune Apparel		Intel Capital
				Round Glass Partners
				Stripes Group
				Harmony Partners
				Valiant Capital
				Warburg Pincus
				Omidyar Network
				Tiger Global Management
				Alibaba Group
				KPCB And Sherpalo Ventures
				Baillie Gifford
				Kinnevik AB

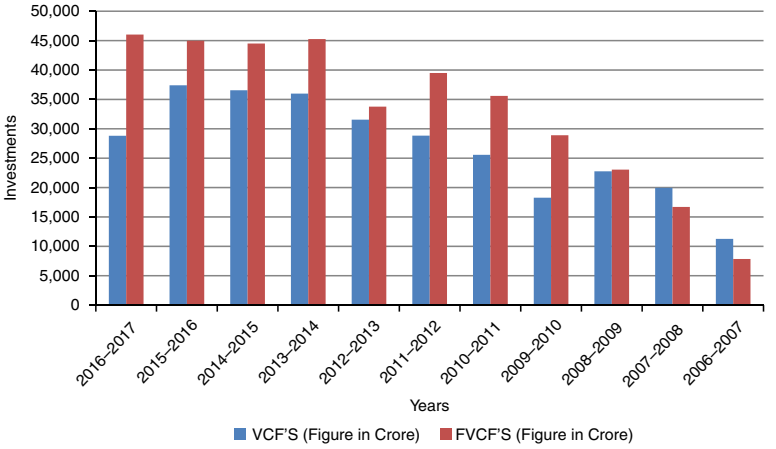
Notes: IDBI, Industrial Development Bank of India; ICICI, Industrial Credit and Investment Corporation of India; NFSIT, National Venture Fund for Software and IT Industry; IFCI, Industrial Finance Corporation of India; CVCF, Can Bank Venture Capital Fund Limited; IL&FS, Infrastructure Leasing and Financial Services Limited; GVFL, Gujarat Venture Capital Finance Limited; APIDC, Andhra Pradesh Industrial Development Corporation; IVML, Industrial Venture Capital limited, KITVEN, Karnataka Information Technology Venture Capital; SIDBI, Small Industrial Development Bank of India

Source: Authors' own compilation from multiple database which includes various annual reports, government documents and websites

Table VII.
List of venture capital fund (VCF's) and FVCF's (foreign venture capital fund) operating in India

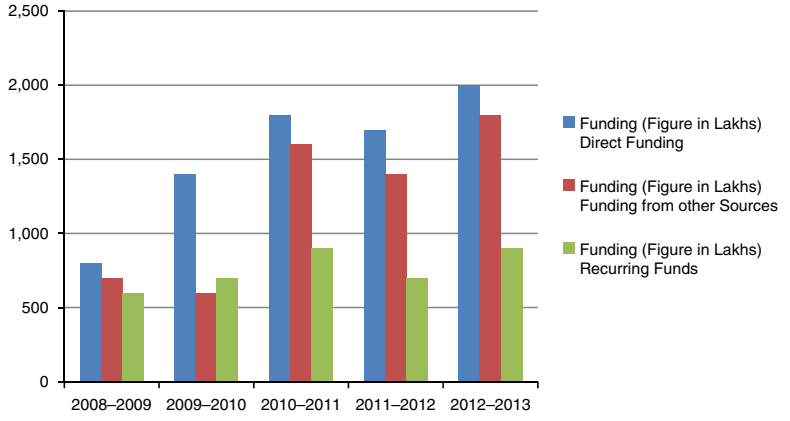
effective model of India's innovation system. Moreover, while mapping the incubation innovation process of India's innovation system following observation has emerged:

- In India, technology incubation is yet too emerged as one of the dominant processes in elevating the innovation process in the country. This is despite the fact that government has initiated the program since 1982 with the establishment of NSTEDB.
- India lacks a significant policy for technology incubation, it is only in 2016 that the government of India has initiated Start-Ups India program.
- The study shows the influence of government funding for the early stage funding, whereas the recurring funding landscape needs more attention.



Source: Own compilation from SEBI (Security and Exchange Board of India) Website www.sebi.gov.in/sebiweb/home/HomeAction.do?doListing=yes&sid=4&ssid=24&smid=0

Figure 7.
Investment of venture capitalist in India



Source: Authors' own compilation from NSTEDB database www.nstedb.com

Figure 8.
Funding opportunity for all incubators

- The study shows an active inclination in the investment by venture capitalist by these funds is mainly meant for the recognized start-ups.
- The study shows an active engagement of both public and private TBI in the incubation process.
- It is quite evident that India's academic portfolio of knowledge production is quite significant with a significant rise in the patent filling procedure by the universities and technological institutes.
- The study reveals the potential of incubation in developing the innovation ecosystem of the country; besides this, the involvement of private player could play a significant role in promoting the R&D expenditure of the country.

Notes

1. Bayh–Dole Act: The Bayh–Dole Act was one of the important act with respect to technology transfer from the university. The act is also known as patent and Trademark Act Amendment came in 1980. According to which the university retains ownership to invention made under federally funded research. In return the university is expected to file patent to ensure commercialization upon licensing. The royalty of such venture is being shared by both inventor and university/college department.
2. The Torch Program was implemented by the Ministry of Science and Technology (MOST) in 1988. The Torch Program is a guiding program for the development of China's high and new technology industry. The core mission of the Torch Program is to give scope to the advantages and potentials of China's scientific and technological forces and accelerate commercialization of high and new technology achievements, industrialization of high and new technology products and internationalization of the high and new technology industry with market as the orientation.

References

Aernoudt, R. (2004), "Incubators: tool for entrepreneurship?", *Small Business Economics*, Vol. 23 No. 2, pp. 127-135.

Al-Mubaraki, H.M., Muhammad, A.H. and Buster, M. (2015), *Innovation and Entrepreneurship Powerful Tools for a Modern Knowledge-Based Economy*, Springer, New York, NY.

Arnold, D.J. and Quelch, J.A. (1998), "New strategies in emerging markets", *Sloan Management Review*, Vol. 40 No. 1, pp. 7-20.

Basant, R. (2011), "Innovation policy in India: ongoing experiments and emerging challenges", Annual Meting of American Political Science Meeting, Seattle.

Bruneel, J., Ratinho, T., Clarysse, B. and Groen, A. (2012), "The evolution of business incubators: comparing demand and supply of business incubation services across different incubator generations", *Technovation*, Vol. 32 No. 2, pp. 110-121.

Bulsara, H., Gandhi, S. and Porey, P.D. (2009), "Techno-innovation to techno-entrepreneurship through technology business incubation in India", *Asia Pacific Journal of Innovation and Entrepreneurship*, Vol. 3 No. 1, pp. 55-77.

Chandra, N. (2009), "Indian institutes of technology and the pursuit of capitalising knowledge", *Contemporary Perspectives*, Vol. 3 No. 2, pp. 258-292.

Chandra, N. and Krishna, V.V. (2009), "Academia-industry links: modes of knowledge transfer at the Indian Institutes of Technology", *International Journal of Technology Transfer and Commercialisation*, Vol. 9 Nos 1-2, pp. 53-76.

Chandra, A., He, W. and Fealey, T. (2007), "Business incubators in China: a financial services perspectives", *Asia Pacific Business Review*, Vol. 13 No. 1, pp. 79-94.

Edquist, C. (1997), *Systems of Innovation: Technologies, Institutions and Organizations*, Pinter/Cassell Academy, London.

Eisenhardt, K.M. and Martin, J.A. (2000), "Dynamic capabilities: what are they?", *Strategic Management Journal*, Vol. 21 Nos 10-11, pp. 1105-1121.

Etzkowitz, H. (2002), "Incubation of incubators: innovation as a triple helix of university industry-government network", *Science and Public Policy*, Vol. 29 No. 2, pp. 115-128.

Eveleens, C.P., van Rijnsoever, F.J. and Niesten, E.M. (2017), "How network-based incubation helps start-up performance: a systematic review against the background of management theories", *The Journal of Technology Transfer*, Vol. 42 No. 3, pp. 676-713.

Freeman, C. (1987), *Technology and Economic Performance: Lessons from Japan*, Pinter Publication, London.

Hekkert, M.P., Suurs, R.A., Negro, S.O., Kuhlmann, S. and Smits, R.E. (2007), "Functions of innovation systems: a new approach for analysing technological change", *Technological Forecasting and Social Change*, Vol. 74 No. 4, pp. 413-432.

Kimatu, J.N. (2016), "Evolution of strategic interactions from the triple to quad helix innovation models for sustainable development in the era of globalization", *Journal of Innovation and Entrepreneurship*, Vol. 5 No. 1, pp. 1-7.

Krishna, V.V. (1991), "The emergence of the Indian scientific community", *Sociological Bulletin*, Vol. 40 Nos 1-2, pp. 89-107.

Lala, K. (2016), "Role of innovation in technological business incubation in India", unpublished MPhil Dissertation, Central University of Gujarat, Gandhinagar.

Lundvall, B.A. (1992), *National Innovation System: Towards a Theory of Innovation and Interactive Learning*, Pinter Publisher, London.

Mani, S. (2015), "UNESCO science report towards 2030", United Nations Educational, Scientific and Cultural Organisations, Paris.

Manimala, M.J. (1997), "Higher education-enterprise cooperation and the enterpreneurial graduates: the need for a new paradigm", in Mitra, J. and Formica, P. (Eds), *Innovation and Economic Development*, Oak Tree Press, Dublin, pp. 95-118.

Manimala, M.J. and Vijay, D. (2012), *Technology Business Incubators (TBIs): A Perspective for the Emerging Economies*, Indian Institute of Management, Bangalore.

Marda, V. (2015), *Technology Business Incubators: An Indian Perspective & Implementation Guidance*, Centre for Internet & Society, available at: http://cis-india.org/internet-governance/blog/technology-business-incubators.pdf (accessed September 5, 2016).

Matt, M. and Tang, M.F. (2010), "Management of university incubators in China and in France: a comparative analysis", *International Journal of Entrepreneurship and Innovation Management*, Vol. 11 No. 3, pp. 282-301.

Mowery, D.C. and Sampat, B.N. (2004), "Universities in national in national innovation systems", in Fagerberg, J., Mowery, D.C. and Nelson, R.R. (Eds), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, pp. 209-239.

Mazzoleni, R. and Nelson, R.R. (1998), "The benefits and costs of strong patent protection: a contribution to the current debate", *Research Policy*, Vol. 27 No. 3, pp. 273-284.

Nelson, R. (1993), *National Innovation System: A Comparative Analysis*, Oxford University Press, Oxford.

Ojha, A.K. (2009), "Innovation and enterpreneurship in the Indian IT industry: contextual impediments", in Manimala, M.J., Mitra, J. and Singh, V. (Eds), *Enterprise Support System: An International Perspective*, Sage Publication, New Delhi, pp. 89-106.

Phillips, R.G. (2004), "Technology business incubator: how effective as technology transfer mechanism", *Technology in Society*, Vol. 24 No. 3, pp. 299-316.

Rajan, A.T. and Jain, A. (2012), "India venture capital and private equity report", Indian Institute of Technology Madras, Madras.

Schumpeter, J. (1934), *Capitalism, Socialism, and Democracy*, Harper and Row, New York, NY.

Sikka, P. (1997), "Financing the development and commercialization of indigenous technology in India", *Current Science*, Vol. 73 No. 5, pp. 406-408.

Sonne, L. (2012), "Innovative initiatives supporting inclusive innovation in India: social business incubation and micro venture capital", *Technological Forecasting and Social Change*, Vol. 79 No. 4, pp. 638-647.

Tang, M., Baskaran, A., Pancholi, J. and Lu, Y. (2013), "Technology business incubators in China and India: a comparative analysis", *Journal of Global Information Technology Management*, Vol. 16 No. 2, pp. 33-58.

Tang, M., Baskaran, A., Pancholi, J. and Muchie, M. (2011), "Technology business incubators in China and India", *African Journal of Science, Technology, Innovation and Development*, Vol. 3 No. 2, pp. 248-290.

United Nations Publication (2004), *Promoting Business and Technology Incubation for Improved Competitiveness of Small and Medium-Sized Industries Through Application of Modern and Efficient Technologies*, United Nations Publication, New York, NY.

Wissema, J.G. (2009), *Towards the Third Generation University: Managing the University in Transition*, Edward Elgar Publishing, Cheltenham.

Further reading

Charry, G.P., Perez, J.E. and Barahona, N.E. (2014), "Business incubator research: a review and future directions", *Pensamiento y Ggestión*, Vol. 37, pp. 41-65.

About the authors

Kanchan Lala is presently a PhD Researcher Scholar at the Center for Studies in Science, Technology and Innovation Policy at Central University of Gujarat, India. He received aMaster's Degree in Development Studies and MPhil Degree in Science, Technology and Innovation Policy from the Central University of Gujarat. His research interest studies lies in exploring the domain of technology incubation, foresight analysis, national system of innovation and entrepreneurship, within the larger theme of inclusive and sustainable growth. Kanchan Lala is the corresponding author and can be contacted at: kanchanlala@hotmail.com

Dr Kunal Sinha is currently Assistant Professor at the Center for Studies in Science, Technology and Innovation Policy at Central University of Gujarat. He received MPhil and PhD Degrees in Science Policy from Jawaharlal Nehru University, New Delhi. He specializes in the area of science, technology and innovation policy and teaches innovation and socio-economic change, technology futures analysis, IPR, and research methodology.