Innovation and competitiveness among the firms in the Automobile Cluster in Pune

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Abstract

Automobileoriginal equipment manufacturers (OEMs) are expanding their production bases to emerging economies to expand their market reach and leverage the existing capacity for auto-component manufacturing (SMEs) and provide opportunities for suppliers and subcontractors (SMEs) to build innovation capabilities leading to better performance. The innovation systems perspective and global value chain perspective contributes to develop important framework for evaluating innovation performance and maintain competitiveness of firms. These firms utilize external source of innovation and knowledge spillover externalities at cluster.This study explores firm's technological innovation capabilities and economic performance in the Pune automobile cluster. Empirical evidence shows that how firms can interact with Innovation Systems and Global Value Chainperspective to build innovation capabilities (technological capability, manufacturing capability, organizational capability, strategic planning capability and marketing capability). The structured equation modeling (SEM) has been performed to test hypotheses and results enable us to know how firms' utilize external source of innovation and enhance their innovation capabilities and achieve global competitiveness.

Keywords: Automobile cluster, innovation capabilities, competitiveness and framework for technological innovation performance

1. Introduction

The automobile industry in India has gone through a lot of transformation in the last two decade. With the liberalization and globalization process starting in 1991, the industry has seen the entry of international automobile majors in India. Along with the automobile original equipment manufacturers (OEMs), auto component industry has transformed itself from a traditional job fulfiller role to an integrated organization role (Sahoo*et al* 2011).The process of technological development in Indian automobile industry can be seen in the auto-clusters. Automobile clusters are developed in North (NCR-Uttaranchal), East (Jamshedpur–Kolkata), South (Chennai-Hosur-Bangalore) and Western (Mumbai-Pune-Aurangabad) regions. Based on technology dynamism and competitiveness, clusters have experienced all the phases of life cycle: pre-foundation phase (1945-1965), emergence phase (1966-1984), growth phase I (1985-1995), growth phase II (1996-2007), sustenance Phase (year 2008 onwards). Further the Indian automobile cluster life cycle has been influenced by policy framework of the government and has considerable impact on growth of industry fostering innovations and global competitiveness.

Indian government has contributed in automobile industry growth by liberalizing the norms for foreign direct investment (FDI) and import of technology in 1990s. As a result, the production of total vehicles increased from 4.2 million in 1998-99 to 10.7 million in 2011-12 (SIAM 2012). Due to intense competition and changing customer demand, product development process advances have been more significant than changes in the product architecture. Product cycles continue to grow shorter as more companies adopt the simultaneous engineering approach pioneered by Japanese automakers. The degree of scale economies in the industry is closely associated with the flexibility of the technology to constantly produce different models from the same platform. Some of the major technological issues of currentimportanceare increasing energy efficiency, competency of internal combustion engine (ICE), reducing the weight of vehicles, incorporating high-tech safety features, and emission norms etc (Nag*et al* 2007). Simultaneously, the gradual opening up of the auto-component sector, government extending support to the development of domestic critical component and sub-system suppliers through improvement in the investment environment, stronger patent regimes and incentives for R&D.

Uchikawa and Roy (2010) studied development of auto-component industry and identified six major sources of information to improve productivity and quality of products: R&D through imitation, customer suggestions, and training of engineers (provided by suppliers of machinery), cluster development programme organized by ACMA or assemblers, and technical and foreign collaboration. An important issue which was given only limited attention in the literature on technology and large-scale industrial development in India: the inter-firm, network based nature of the processes of change and technological capabilities. While the importance of the individual large firm's own technological change generating capabilities (Basant R *et al* 2002, Okada *et al* 2007, Sudhirkumar*et al* 2011) has been emphasized, it has also been recognized that technological change usually depends on externally sourced inputs like flow of FDI towards technology development, and technology transfer through collaborations in automobile industry.

More recent perspectives i.e. innovation systems and global value chain perspective have therefore come to highlight the importance of the dual structure of internal change-generating innovative resources and links to external sources of technology.The innovation systems perspective based on the assumption that technological learning and innovation not only includes economic transactions but also interactive processes involving actors, institutions and social norms (Nelson 1983, Lundvall 1992). The Innovation Systems perspective (refers tothe national, regional, or local level) emphasizesthe crucial role of technological trajectories and institutionalassets in collective learning, giving a specialimportance to the environment that stimulates technological learning and innovation. Therefore,the organizational and culturalproximity of agents are crucial in local capacity building.

The global value chain perspectivefocuses on the analysis of international linkages among firms in worldwide production and distribution systems, emphasizing the role of leading companies that carry out functional integration and coordinate international dispersed activities (Giuliani *et al*, 2005). Global chains operate in highly competitive global markets, fostering the need of MNCs/TNCs to transfer technical and managerial capacities to their local affiliates and suppliers, so that these firms will be able to fulfill the quality standards and lower their production costs. Once the local firms have managed to raise their capability levels, the new standards become an incentive to delegate more sophisticated knowledge and processes to these local suppliers (Ernst, 2000; Ernst & Kim, 2002; Schmitz, 2004).

These perspectives have recently been seen as important for understanding the technological dynamics of late industrialization in India. From the point of view of the local economies, three elements define the rationality of the global value chains. First, they allow global OEMs to maintain their competitiveness by giving them access to specialized suppliers in locations with low costs and flexible responses to their requirements. Second, the global OEMs need to transfer knowledge to their local suppliers to improve the technical and administrative abilities of these firms, enabling them to meet the technical specifications of the leading corporations. Finally, only when they have developed their own capabilities can local suppliers effectively absorb the knowledge disseminated by OEMs. The effectiveness of the transfer will depend not only on the quantity and quality of the knowledge but also on the local suppliers' capacities to absorb that knowledge (Ernst, 2000; Ernst & Kim, 2002; Schmitz, 2004).Local companies' collaboration with MNCs often provides them with vital technologicaland organizational training, resources that often they use strategically to develop their market networks and their innovative capacity in the home market (Ivarsson&Alvstam, 2005; Sudhir Kumar *et al* 2010).

Hence, the important aspects for knowledge transfer and absorptive capacity in order to build innovation capabilities depends on how the global value chain and the cluster assets fit together. Local companies' absorptive capacity (external source of innovation) has not only related to their own attributes, it also involves the characteristics of the cluster environment and its institutional support framework. Local suppliers can effectively absorb the knowledge disseminated by the lead firms only when they have developed their own capabilities. The institutional framework (the innovation systems at the national or regional/Cluster level) has a major role in that process.Studies on technological learning and upgrading of local companies linked to global OEMs emphasize dual role. On one hand they limit, subordinate and frequently exclude the participation of local companies; but on the other hand they facilitate the access to global markets and the acquisition of technical and managerial knowledge to improve the position of local companies within the value chains (Contreras *et al* 2012).

The aim of this research is to probe innovation systems perspective and global value chain perspective to develop researchframework to build innovation capabilities among auto-component manufacturing industry (SMEs). Based on this framework we study Pune automobile cluster to evaluate innovation performance of firms within the cluster and find competitiveness of the cluster. This empirical researchhas also focused on understanding how firms can interact with both Innovation Systems and Global Value Chain perspectives to build innovation capabilities.

The paper is organized as follows. The section 2 covers review of literature on significance of cluster development and innovations leading to competitiveness. How inter-firm linkages within cluster positively support to create innovative resources and innovation capability fostering SMEs development and evaluate changing perspectives in prominent segment of India – automobile industry. In section 3, the conceptual research framework is developed as a determinant of innovation and competitiveness in Pune automobile cluster. Section 4 explores link between externalities at cluster level with firm innovation system and develops research framework and hypotheses. The research methodology, sample selection and data collection procedure is also given in this section. Finally, result validates research framework and defines scope for future work.

2. Review of Literature

2.1 Development of clusters, Innovation and Competitiveness

Porter (2003) observed that technology is among the most prominent factors that determine the rules of competition at clusters. Betz (1994) has proposed that technology strategy is realized in practice through the enactment of several key tasks such as, internal and external technology sourcing, deploying technology in product and process development, and using technology in technical support activities. In turn, performing these activities provides change in the firm's technical competencies and capabilities. Technology is considered to be a major competitive factor for the countries at macro level and for individual firms at micro level. The Global Competitiveness Report (2000) introduces a new focus: technology as one of the key drivers of sustained economic growth.

Technology has influenced cluster development process in developing countries. Cluster development process studied by Menzel*et al* (2007) found that dynamism plays an important role between growth and sustenance phase of cluster life cycle. This dynamism mostly happens due to heterogeneity of knowledge, technological and innovation capabilities of firms within cluster. Technological capabilities are uneven within a same cluster, which is largely due to differences in the firms' ability to bring about technological paradigm and trajectory shifts (Narayanan K, 1998). The competence of cluster depends on the level of accumulated technological capability through learning relationships and in-house R&D efforts and innovation capability.

The literaturesuggests that in context of the clusters different kinds of technological capability play different (possibly unequal)roles in sustaining long-term competitiveness. It has been usual practice to placetechnological capabilities in functional categoriesrelated to the kind of activities which theyfacilitate, for instance: production capabilities,investment capabilities and linkage capabilities; but often with "innovation capabilities" identified separately from these functional categories (Yam *et al*, 2011).The most important contribution made by research on technological change in the large-scale industrial sector in emerging economies has been its clarification of the central role of firms and specific resources (people, knowledge and organizational arrangements) as the drivers of technological change to build capabilities.The Automotive Mission Plan (2006), released by the Government of India, also gives due prominence to technology development and has identified several initiatives to enhance competitiveness in manufacturing and technology development.

2.2 Cluster inter-firm linkages, Innovation capability and SMEs development

In last one decade, firms are continuously improving their ability to carry out innovations, which act as strategic weapon to counter global competition. The relationship between innovation and firm performance has been explored in many studies as shown in Table 2.1. Innovative capability of firm is identified as one of the major factors for the enhancement of performance of firm (Yam *et al* 2004; Deshpande*et al* 1993; Edwards and Delbridge 2001). Normally, these capabilities of firm are focused on product and process innovations, which may be incremental or radical. The meaning and impact of these innovations changes based on type of firm, for instance, auto-component firm's product innovation (incremental or radical) becomes part of process innovation of auto-firms. So, firms within cluster are need to possess technological and innovation capabilities. It is unlikely to find all these capabilities in the same firm and they do not innovate in isolation by focusing on in-house R&D, but involves other firms as a part of innovation process.Innovative activity is the strongest among firms that combine their in-house R&D efforts with technical support from external sources (Macpherson 1997).

Table 2.1: Study approaches and major factors in assessing technological and innovation capabilities

study approach	*technological and innovation capability factors*	*References (proposed by)*
Functional Approach	▪ Investment Capability ▪ Production Capability ▪ Linkage capability	Lall Sanjay (1992)
Process Approach	▪ Concept generation capability ▪ Process innovation capability ▪ Product development capability ▪ Technology acquisition capability ▪ Leadership capability ▪ Resource deployment capability ▪ Capability in effective use of system and tools	Chiesa*et al* (1996)
Functional Approach	▪ Technological acquisition capability ▪ R&D capability	Narayanan K (1998, 2001)
Process Approach	▪ Capabilities of firm in resource availability and allocation ▪ Understanding competitor innovative strategy and market ▪ Technology development relevant to firm ▪ Structural and cultural affecting internal innovative activities ▪ Strategic management capability to deal with internal innovative activities	Burgelman*et al* (2004)
Functional Approach	▪ Learning capability ▪ R&D capability ▪ Resource allocation capability ▪ Manufacturing capability ▪ Marketing capability ▪ Organizational capability ▪ Strategic Planning capability	Yam *et al* (2004)
Process Approach	▪ Firms technological capability based on learning patterns	Guo*et al* (2010)
Process Approach	▪ Firms innovation capability based on assistance: product related, production process, organizational know-how, marketing, financial and purchase process related from TNCs	Sudhirkumar*et al* (2010)

Innovative performance of SMEs is influenced by internal factors and external factors. Romjin and Albaladejo (2000) found important internal factors for SME firms to develop their innovative capabilities are owners' technical education and prior working experience, technical skills of workforce and investment in R&D and training. In general, SMEs are constrained in-terms of their in-house resources to carry out innovations, which are crucial for their performance enhancement. Major barriers to innovation in SMEs are related to the lack of skilled workforce, market uncertainty, financial risk associated with investment in innovations, the lack of technical know-how and cost of innovation. Technology acquisition in developing countries can be related to three major resources, for instance, adaptive, basic or innovative research through in-house R&D efforts; arm-length purchase of design and drawings through payments of royalty or fees; and import of capital goods with embodied technology (Narayanan and Bhat, 2009). Hence ability of these firms to innovate depends on access to external sources of innovations.

In Indian automobile industry joint ventures and technical collaboration played vital role as a source of innovation for local auto-component supplier firms. Acquiring knowledge and skills through external collaboration has become an effective and efficient way towards the success of innovation within clusters (Okada, 2007).Firms in clusters have frequent interactions, which are mainly reflected in the acquisition of knowledge, as well as in sharing, diffusing and creating it. A host of linkages among cluster member's results in learning through networking and interacting, it is seen as the crucial force pulling firms into clusters and the essential ingredient for the ongoing success of innovative activities in cluster (Breschi and Malerba, 2001). Innovation related knowledge is diffused in clusters in a highly selective and uneven way (Morrison, 2004) indicating inter-firm differences.

2.3 Indian automobile and auto-component Industry

Indian automobile industry comprises of the auto and the auto-component industries. The automobile industry in India has witnessed changing technological landscape in the global automotive industry (Narayanan 1998) and working in terms of the dynamics of an open market (Sahoo*et al* 2010). India is currently world's second largest market for 2-wheelers (2W), 9th in passenger cars (PV) and 8th in commercial vehicle (CV) production globally (SIAM 2012). Many joint ventures have been set up in India with foreign collaboration, both technical and financial with leading global automobile manufacturers. Also a very large number of joint ventures have been set up in the auto components sector. The large volumes of investment including foreign direct investment in the automobile manufacturing ventures and technical collaboration are propelling a quantum jump in up-gradation of technology. As per the Automotive Mission Plan (2006), released by Ministry of Heavy Industries and Public Enterprises, Government of India, the turnover of the industry is expected to increase to USD 145 billion by 2016 and exports are expected to touch USD 35 billion by that time with better choice in design. The increased production and capacity creation in the automobile sector specifically passenger cars is going to accelerate the continuous growth of the auto component industry as well.

The principle feature of the Indian auto component industry is that it is a high investment sector of the economy with state-of-the-art technology, and serving a large number of vehicle models. As per the industry statistics from Automotive Component Manufacturers Association (2012), there are over 550 key players in the auto component sector with a total turnover of USD 43.5billion in 2011-2012. The Indian auto component industry produces a comprehensive range of components, which include engine parts, drive transmission and steering parts, suspension and braking parts, electrical parts, equipment and other parts. Over the years, the industry is successfully working on the path to fulfill its mandate of localization and moving toward being global suppliers. As per ACMA statistics, the auto component exports has risen from USD 760 million in 2002-2003 to USD 6.8 billion in 2011-2012, amounting to 19 percent of total output. Technology development in the auto component industry worldwide has been primarily driven by the automobile manufacturers, regulations and changing customer preferences. In India, the technology development has followed the developments in the developed world and thus technology acquisition through collaborations and alliances has been one of the preferred routes (Narayanan, 1998).

In the fast changing global scenario, the auto component industry in India faces many challenges. Some of the major challenges are greater competition in domestic as well as export markets, integration into the global supply chain, quality level, low overall technology level in-terms of product design/manufacturing/other technologies in the value chain, etc. The auto component manufacturers in India have responded to the challenges in a major way by going in for technical collaborations and joint venture and upgrading the product development and manufacturing capability. The concept of attaining competitiveness on the basis of abundant and cheap labor, favorable exchange rates and concessional duty structure is becoming inadequate and therefore, not sustainable. The key question is how quickly the industry is able to adapt to the challenges of the fast changing environment and how well the industry is able to integrate the technology management and innovation with the business strategies of the firms.

The literature brings out the need of SMEs to build innovation capability through external source of innovation and knowledge spillover from large domestic and global OEMs leading to better economic performance.

2.4 Need of Present Study

The Indian automobile industry is facing new challenges and organizing them in-order to catch advanced technological path. The emergence of global OEMs specifically in the segment of passenger vehicles and large domestic auto players new product launches, created technological dynamism within industry and focused on technological and innovation capabilities of both auto and auto-component supplier firms. The technological dynamism needed to sustain the competitiveness of a spatially clustered network of firms supplying components and services to the automobile industry in India depends on a knowledge spillover and better absorptive capacity from local firms to reduce technology gap (Bell M. and Albu M, 1999).

The Industry has implemented both Safety & Emission regulations with International Standards for sustained growth of the Industry for combating the environment and become a global export hub. All auto clusters has a well-established and Regulatory Framework under the Ministry of Shipping, Road Transport and Highways. India is harmonizing its Emission Norms for Four Wheelers with the European Regulation and has adopted Euro III, equivalent norms in 11 Metropolitan Cities from April 2005. For Two Wheelers, which constitutes 70% of the vehicle population unique Indian emission norms, which are one of the tightest in the world have been adopted.The Safety Regulations are being aligned with the ECE regulation.Thus, automobileindustry has concentrated on green and clean technology and to some extent focusing on hybrid vehicles.

The most studies in the existing literature have concentrated on theoretical discussions on the composition of innovation actors. Yam*et al* (2011)insisted that the problem of measuring innovation effectiveness at the regional level had not yet been completely resolved. No empirical analysis in automobile industry yet taken place on how a firm can interactwith the perspectives i.e. innovations perspective and global value chain perspective to enhance its capacity to innovate and achieve global competitiveness.

Hence, the main research gap identified from literature review:

a. In emerging economy like India, different aspects of technological and innovation capabilities like R&D capability, specialized skills for R&D, manufacturing capability, organizational capability, strategic planning and marketing capability of SMEs (auto-component suppliers and subcontractors) have not studied at automobile cluster.
b. Sustainable competitiveness of firms within cluster influenced by innovation capability factors (mostly technology dimensions) has not been studied at Indian automobile cluster context.

3. Determinants of Innovation and Competitiveness: Pune Auto-Cluster

In Indian automobile cluster, the leading auto and auto-component firms played the role of technological "gatekeepers" in clusters. It is evident that, large firms within clusters be critically important in providing new knowledge inputs for smaller clustered firms (Okada, 2007). This certainly seems to have been the case in NCR region auto-cluster, Chennai auto cluster and Pune auto-cluster. Technology support organizations also play important knowledge "gatekeeper" roles at the boundary of cluster knowledge-systems. Some of these may be public sector institutes, with varying degrees of support from local firms, which carry out research, or provide technical or training services - for instance, ARAI, ACMA, SIAM and NATRiP.

The influence of extra-cluster innovation on intra-cluster diffusion occurred through joint ventures, strategic alliances for technology and acquisitions at host country in automobile industry. In NCR automobile cluster,MarutiUdyog Ltd.started in 1982 as joint venture with Japanese automaker "Suzuki Motor Corporation". The first plant established was close copy of Suzuki's Kosai plant in Japan in-terms of plant layout, equipment, the organization of production and operating principle (Okada A *et al* 2007). Also, it was the first firm to introduce a partial 'just in time' (JIT) and total quality management (TQM) in India, which aims to reduce inventory cost. MarutiUdyog Ltd followed strategy of massive investment in the program of vendor development, involving stable and close supplier relations with its first-tier suppliers (40 top suppliers), equity participation in key suppliers, and promotion of technical collaboration between its suppliers with Suzuki's suppliers in Japan. For example, Bharat Seats has technological ties with Howa Industry, a supplier of seats to Suzuki in Japan; Asahi India has ties with Asahi Glass; Sona Steering received technology from Koyo Precision Industry; and Subros received technology from Denso.

The critical role has played by lead firms in the development of the Chennai auto cluster, including the TVS Group, the Rane Group, and Ashok Leyland Ltd. Ashok Leyland Ltd., established in 1948 as Ashok Motors, entered into an agreement with Leyland Motors, U.K., to manufacture Leyland vehicles. Another group firm, Lucas-TVS, a joint venture with the Lucas Variety group, UK and the TVS group, was established in 1961 and is a leading manufacturer of auto electrical products and diesel fuel injection equipment in India. Other group firms such as Brakes India, Sundaram Clayton Ltd., SundaramFastners Ltd., and Turbo Energy Ltd., were all established in the 1960s, as joint ventures with British firms. The Rane Group has also emerged and playing dominant role in India. During 1996 and 1999, the arrival of Ford, Hyundai and Hindustan Motors Ltd. (via a licensing agreement with Mitsubishi Motors) further transformed the Chennai auto cluster, as they have established passenger car production and assembly operations in Chennai. Hyundai has set up a 100 percent subsidiary firm (its largest investment outside South Korea) in 1998. It initially brought about 14 South Korean component suppliers to the Hyundai plant in India, to supply components that are not available in Chennai and developed existing auto-component manufacturer belt.

In Mumbai-Pune automobile cluster, same trend has been observed. Yet Tata Motors (TELCO then) emerged as giant and developed their own huge supplier base. Recently, TATA group observed acquisition strategy for technology development. Similarly, Mahindra and Mahindra and Bajaj Tempo played important role in the region through joint ventures and developed quality products. Also presence of global OEMs created dynamism in the region and started developing local suppliers through joint venture of their host country vendors. Hence, the research emphasized the role of domestic and global OEMs towards technology diffusion among auto-component supplier firms within the cluster as the dominant factor for building technological and innovation capability.

3.1 Pune Automobile Cluster

Pune has been emerging as a prominent location for the automobile sector and having advantage of large supplier base as well as proximity of the NhavaSheva port. It is home to the Automotive Research Association of India (ARAI), which is responsible for the homologation of all vehicles available in India along with automobile R&D, testing and certification organization. All sectors of the automobile industry are represented, from two-wheelers and three-wheelers to cars, tractors, tempos, excavators and trucks. Automobile and related industry in pune comprises 1106 companies (MCCIA, 2012), out of which 396 SMEs established during year 2008-2011. However, SIAM and ACMA members are only 189 firms. Automobile companies like Tata Motors, Mahindra & Mahindra, Bajaj Auto, Mercedes Benz, Force Motors (Firodia-Group), Kinetic Motors have established in Pune. Automobile companies including General Motors, Volkswagen, and Fiat have set up green-field facilities near Pune recently. Several automobile component manufacturers like Bharat Forge, Autoline, Kinetic engineering, Saint-Gobain Sekurit, TATA Autocomp Systems Limited, Bosch Chasis, ZF Friedrichshafen AG, Visteon, DGP Hinody, TACO group, NRB and SKF Bearings, and foreign auto-component suppliers are located in the cluster. The ownership pattern of Pune-based auto component companies is largely dominated by private players forming 67% of the entire sample, followed by proprietary and partnership firms that accounted for 20% and 13%, respectively.

Pune cluster has also gained strength from the arrival of global OEMs and creating competitiveness through domestic vendor development encouraging foreign tie-ups for specific technology. Tata Motors invested about Rs 6,000 crore over a four to five year period in its existing plants and for the setting up vehicle testing facilities. Further, IBM has set up a new Global Delivery Center in Pune to provide auto majors, among other industries, business consulting and application services. It offers a wide range of services that cover key areas such as product lifecycle management, manufacturing productivity, business consulting, human capital management, financial services, technology services, and solutions for small and mid-size automobile manufacturers. ARAI has tied up with TUV Rheinland, a 130-year-old German multinational and one of the world's largest testing, inspection and certification agencies, to offer testing and homologation solutions to the Indian and international automobile industry. With this association, the Indian manufacturers will have an edge in exports of vehicles and vehicle parts as all the aspects of testing and certification as per international standards like EEC/ECE will be handled locally by qualified experts.

The cluster witnessed the entry of new global OEMs, diversification of the production and introduction of new products. Technological paradigm shift ranges from New Product launches to the introduction of differentiated products involving updated technology. Firms within cluster tend to form collaborative organizations to promote and exploit these linkages, and other institutions (such as university, research institutes and supportive institutions) tend to strengthen their information links. The increasing strength of such technological capability efforts, knowledge integration, systemic effect (networks) can be major factor to enhance performance of cluster. The small car segment, which once used to be a predominantly petrol engine segment, is witnessing rising diesel penetration. Most of the OEMs (except Honda) now have diesel variants in their small car portfolio that co-exist with petrol variants. Mid-size car segment has high diesel penetration and shift towards diesel driven vehicles has also contributed to the growth recently.

An automobile is a complex machinery bringing together thousands of both functional as well as safety-critical parts that must function reliably as a system over an extended period of over 10 years while meeting the extant safety and emission norms. These investments are generally spread over a time horizon of 2-4 years, representing the duration between conceptualization and mass production. The development cycle of a new model involves multiple phases including market survey, feasibility study, design, engineering, development and validation of individual parts, assemblies and fully-built vehicles. In terms of technological positioning, although the Pune auto component manufacturers may lack design know-how in certain product categories, their overall capability in manufacturing auto components, with consistent quality and reliability has now well acknowledged. Auto models like Ford Figo, Honda Brio, Nissan Micra, Toyota Liva and Volkswagen Polo has 75% localized products. Additionally, most global auto players are setting up capacities to locally develop and manufacture engines and transmissions in India with vendor development forming a key part of their strategy, which is not their earlier.

The major products from the Pune cluster are clutch components, gear components, brake components, shafts, axles, valves, engine components, electrical components, etc. The Auto Cluster Project was set up under the Industrial Infrastructure Up-gradation Scheme (IIUS) of the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry along with the Pimpri-Chinchwad Municipal Corporation. The first phase of the project began with an investment of Rs 124 crore and is up and running. Currently, there are CAD/CAM, rapid prototyping, calibration, environment testing, rubber and polymer component testing facilities. Pune automobile cluster observed the growth and capability development through joint ventures and technology collaborations. The performance of joint ventures for Technology Alliances has mixed results as some of them have parted ways (M&M-Renault; TML-Fiat; Hero-Daimler) and others restructured their business plans (Force-MAN). At the same time, foreign OEMs have preferred bringing in their global auto-component suppliers in the Indian Market through Tie-ups or Joint Venture with local companies (Technology Transfer). Also they have resorted technology/platform sharing alliances to fill gaps in their product portfolios. Some of the OEMs are sharing manufacturing facilities. Maruti Suzuki's technology sourcing for diesel engine from Fiat, Renault-Nissan (production sharing) and GM-SAIC (plans to introduce platforms from SAIC's portfolio) are some of the examples of recent collaborations in the Indian automobile space. In response to such a scenario, such alliances are likely to gain momentum as OEMs aim at rationalizing their investments and maximizing reach through technology, manufacturing and distribution capabilities.

The manufacturing facilities are largely flexible, where these new firms also established a modern shop-floor arrangement which integrates technology for differentiated vehicles. This arrangement enabled the firms to effectively utilize their capacity by changing their product mix and to ensure quality and timely delivery. Also there is change in use of advanced materials to reduce a vehicle weight and improve fuel and drag efficiency. Many of foreign OEMs have established their R&D centers and Pune cluster is gaining outsourcing capabilities in R&D space. These all changes constitute a Technological paradigm shifts and firms following various knowledge acquisition channels leading to inter-firm variation. In this way, technical knowledge and know-how about product design, manufacturing, installation, and component development was diffused into the cluster rapidly. At the same time, more and more specialized suppliers emerged and established steady and ongoing linkages with their upstream producers. Hence, based on comprehensive literature review the conceptual research framework is proposed in next section.

3.2 Conceptual Research Framework

The conceptual research framework is proposed based on literature review as shown in Fig 3.1. It enables us to understand auto-component suppliers and subcontractors (SMEs) relationship with global and domestic OEMs (contractor). SMEs deliver products or services to the contractor as specified by their production requirements. SudhirKumar (2010) explores that subcontracting firms receive assistance from the contractor and the degree of inter-firm linkages between the participating firms has assessed in terms of assistance. He probed the inter-firm linkages and diversity of assistance that SMEs would obtain through subcontracting with TNC in the Indian automobile industry and role of this assistance in their economic performance. The research found that product related and purchase process related assistance emerged as strong linkages and Production process, organizational know-how, marketing, finance and human resource related assistance emerged as weak linkages, and TNC could be important source of technological innovations as well as enhanced economic performance of SMEs.

The literature in the Indian context does not show how these types of assistance build innovative resources and innovation capability among SMEs to enhance cluster competitiveness. The capabilities mostly rests on absorptive capacity and technological learning patters (Guo*et al* 2011) of local firms within cluster, which reduces the technology gap between domestic and foreign firms, increasingthe probability of linkages and spillovers; also the availability,competence and geographic proximity of local suppliers increasesthe likelihood of local sourcing and inter-firm linkages (Contreras *et al* 2012).

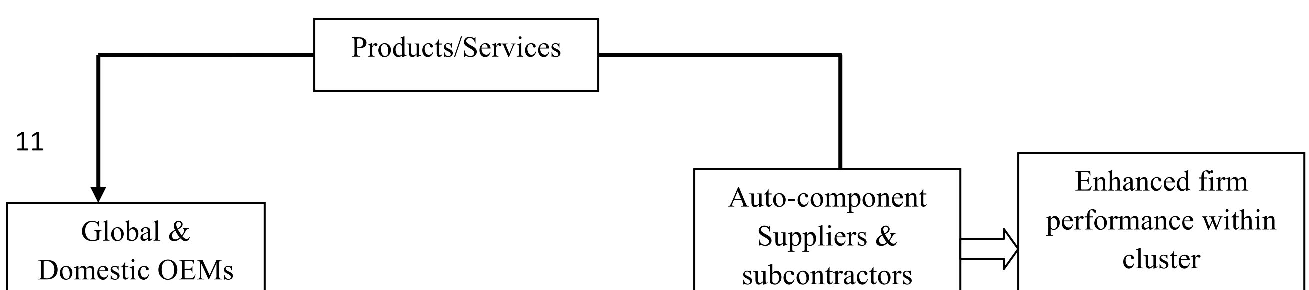

Fig 3.1: The Conceptual Framework for influence of OEMs on innovation capabilities of SMEs and better economic performance

This study explores how sources of innovation and knowledge spillover at cluster (macro-environment) interact with the innovation capability of firms (micro-level environment) to get enhanced technological innovation performance of SMEs. Also SMEs will have to enhance their competitiveness in order to survive and grow in the context of global competition at cluster.

4. Research Framework and Methodology

The research framework is developed based on conceptual framework and validated at Pune automobile cluster.

4.1 Development of Research Framework and Hypotheses

4.1.1 Link between innovation systems and global value chain perspective:

The innovation systems perspective literature describes the link between innovation and competitive and economic outcomes at the national level (Porter, 1990; Nelson *et al*, 1993) and their results have been widely adopted in the national science & technology policy research domain. Moreover, they have collectively formulated an analytical framework for National Innovation System and provided a research background for the study of regional (cluster level) innovation systems (RISs) and firm innovation systems (FISs). Various studies adopted the RIS approach to examine innovating firms in the context of the external institutions, government policies, competitors, suppliers, customers, value system, and social and cultural practices that affect their innovation activities (OECD, 1999). The focus is on the generation and diffusion of knowledge among RIS actors that takes place outside the boundary of the firm. The critical factor to build innovation capability of firm within cluster is 'external source of innovation'. Whereas, the global value chains perspective is concerned with how the dispersal, coordination, and re-integration of value chains among group of firms across region governed, how the institutions seek to influence this governance, and the regional competitiveness and social standards (Gupta *et al* 2008). In this context, domestic lead firms and major global OEMs plays key role. It also emphasis on learning from external sources is critical in emerging economies like India to avoid lock-in at low-end of value chain. External links are important to sustain dynamism of clusters and rejuvenating knowledge flows. Thus it emphasis on knowledge spillovers and collective learning are critical to clusters. However, there is little empirical evidence on how firms harness the benefits of the innovation systems and global value chains perspective to improve their innovation capabilities in automotive industry.

Hypothesis H1: Knowledge spillover derived from global value chain perspective has positive relationship with external sources of innovation at Pune automobile cluster.

Hypothesis H2: External source of innovation derived from innovations systems perspective has positive relationship with knowledge spillover within a Pune automobile cluster

The main feature of this perspective is the ability of the actors to generate, diffuse, and utilize innovations that have economic value, collectively known as the firm's technological and innovation capabilities. The knowledge spillover has influence on sources of innovation to create 'competitive linkages' and 'collaborative linkages' (Contreras *et al* 2012). Innovation activity within a firm is an interactive process characterized by technological interrelatedness between various sub-systems or sub-processes (Teece, 1996). These sub-processes include those of concept generation, product development, production, technology acquisition, leadership, resource provision, and system and tool provision. Innovation capabilities can be enhanced by developing the firm's ability in each sub-process. It is recognized that a firm with greater Innovation Capabilities is able to achieve higher levels of organizational performance and effectiveness and crucial in sustaining its global competitiveness.

4.1.2 External source of innovation:

Earlier studies of source of innovation have focused on firm-specific determinants as in-house R&D activities, manufacturing innovation and firm size. Recent studies on innovative performance of firm have tend to incorporate determinants external to firms, especially with respect to external sources of innovation firms use to develop or improve their products or processes. The source of innovation is important because it determines the capabilities a firm must possess to adopt the necessary innovations in time to achieve success in the marketplace. Studies commented that innovations are not only determined by factors internal to firms, but also by an interactive process involving relationships between firms and different actors in the regional innovation system.

Firms cannot innovate in isolation but they tend to complement their ability to create knowledge in-house by utilizing knowledge from external sources of innovation. This can be achieved by learning by using, learning by doing, and learning by sharing through formal or informal networks within the innovation system. Interaction with external sources of innovation can provide missing external inputs into the learning process that the firm cannot provide itself (Romijn and Albaladejo, 2002) and improve firm performance (Caloghirou*et al*., 2004). Hence, technological innovation can be conceptualized as a learning and utilization process as absorptive capacity (Cohen and Levinthal, 1989). Firms can reinforce their innovation capability by importing technologies and then diffusing, assimilating, communicating, and absorbing them into their organizations (Hamel and Prahalad, 1990). Teece*et al*. (1997) also ascertained that the ability of a firm to acquire, utilize, and develop valuable resources and capabilities are largely related to its acquisition of knowledge external to the firm and its integration of such knowledge.

Hypothesis H3: External source of innovation has positive relationship with innovation capability factors like technological capability, manufacturing capability, organizational capability, marketing capability, and strategic planning capability of firms within cluster.

4.1.3 Knowledge Spillover:

The knowledge spillover plays dual role at cluster level as well as within firm to build innovation capabilities. Knowledge spillover result from dynamism in the information and knowledge flows about products, processes, technologies, consumers and markets, which circulate informally within the system (Lorenzen and maskell, 2004).

Hypothesis H4: Knowledge spillover has positive relationship with innovation capability factors like technological capability, manufacturing capability, organizational capability, marketing capability, and strategic planning capability of firms within cluster.

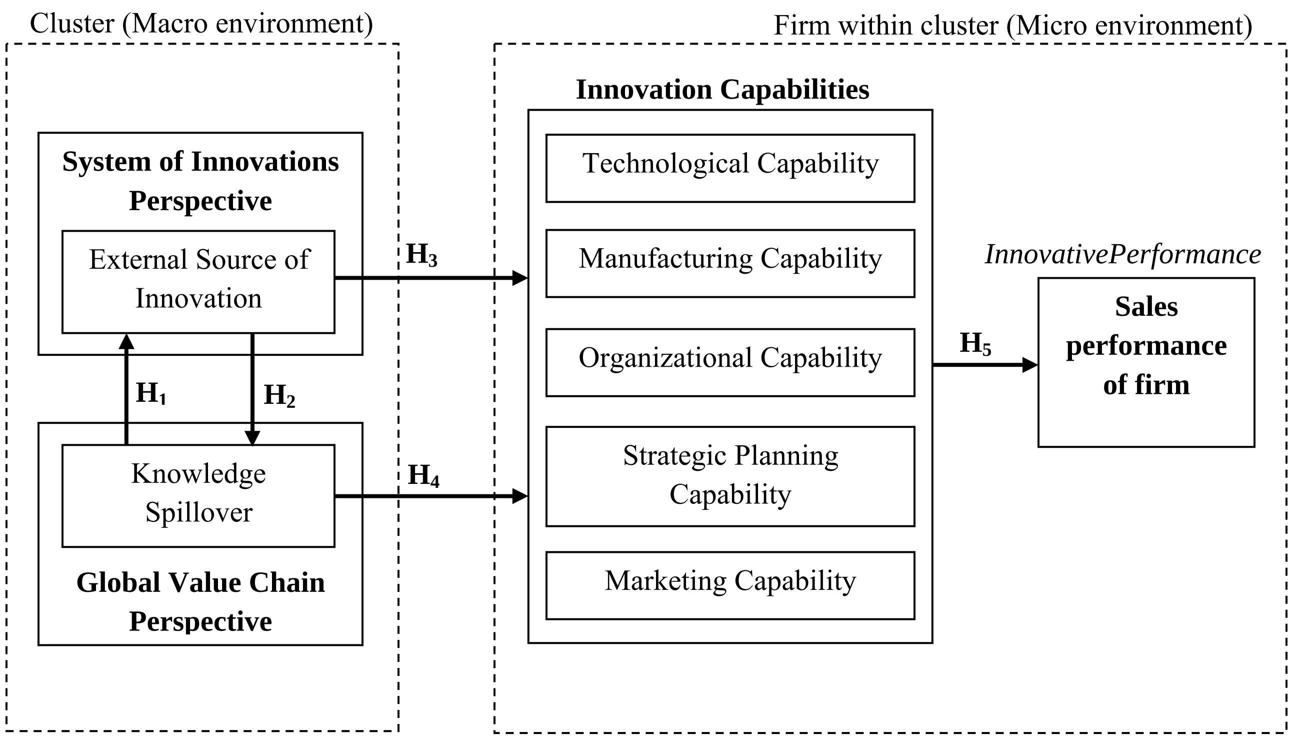

Fig 4.1: Research Framework

4.1.4 Relationship between innovation capability and innovation performance:

A firm's competitive advantage could come from the efficiency and capabilities derived from new product developments (Lawless and Fisher, 1990). An increase in product and process innovation is attributable to the accumulation of capabilities and contributes to innovation outputs. Improving innovation capabilities can be beneficial to the firm and lead to enhanced competitiveness (Yam *et al*., 2004). Narayanan (1998) regarded R&D activities as a central component of firms' technological innovation activities in automobile industry and as the most important intangible form of innovation expenditure (Evangelista *et al* 1997). A firm's heterogeneous resource portfolios (including its human, capital, and technology resources) are responsible for the variability observed in its financial returns. These are the firm's specific competencies that contribute substantially to its sales growth and competitive advantage. There is a causal connection between a firm's resources and its technological innovation performance. The OLSO Manual (OECD, 1997) proposed that Technological and Innovation Performance can be measured by the proportion of sales due to technologically new or improved products, i.e. sales performance. This indicator has also been widely adopted in recent innovation studies (Yam *et al* 2011).

Hypothesis H5: Innovation capabilities like technological capability, manufacturing capability, organizational capability, marketing capability, and strategic planning capability has positive influence on firm's innovative performance within Pune automobile cluster.

These hypotheses tested in Pune automobile cluster and the next section narrates study variables.

4.1.5Study Variables:

The Table 4.1 covers all variables for this research. Based on literature review following major and support variables are defined for study.

Table 4.1: Details of Support Variables to evaluate innovation capability and innovative performance of firms within a cluster

I. Knowledge Spillover		***Variable Name***
1.	The ability of knowledge transfer through available scientific base/publication (codified formal knowledge transfer)	SPILLSCIENCE
2.	Extent of information and knowledge flows about products, processes, technologies, consumer & markets circulate informally within cluster	SPILLINFORMAL
3.	Extent of knowledge transfer due to mobilization of peoples within cluster firms	PEOPLEMOBI
4.	Knowledge spillover through socio-professional and local markets	LOCALSPILL
5.	The percentage of components/products supplied to specific OEM	SUPPLYCOMP
6.	Extent of support in-terms of technical and managerial capacities from MNCs/Global OEMs	SPILLMNC
II. External Sources of Innovations		
7.	The ability of acquisition of embodied technology	TECHEMBOD
8.	The extent of Patent disclosure/scientific knowledge/participation in trade and exhibitions	PATENT
9.	The extent of FDI flows/venture funding/other financial support for Technology development	FDIFLOW
10.	The extent of lead users/customer innovations	CUSTOMERINNO
11.	Extent of strategic technology alliances/international linkages among production and distribution systems	INTLINKAGE

III. Technological Capability		
12.	The ability of in-house R&D/design and development efforts towards product development	RNDPRODUCT
13.	The ability of in-house R&D/design and development efforts towards production process/engineering development	RNDPROCESS
14.	The level of R&D/design and developmentequipment's used	RNDEQUIP
15.	The extent of technology acquisition efforts like technology purchasing/alliance/proprietary technology	TECHAQUISITION
16.	The percentage of specialized skills allocated to R&D/design & Development department	RNDSKILLS
17.	The ability of complex/discrete components being manufactured	COMPLEXCOMP
18.	The extent to which the auto firms (as contractors) provides detailed specifications and designs of the product	SPECIFICS
19.	The extent to which contractor/customer provides feedback on product performance and quality for improvement	FEEDBACK
20.	The extent to which learning patterns/orientation adapted	LEARNING
IV. Manufacturing Capability		
21.	The ability of transforming R&D/design and development output into production	RNDPRODUCTION
22.	The ability of applying advanced manufacturing methods like JIT,TQM, Six Sigma, Toyota production system etc/degree of automation	ADVMFGMETHO
23.	The ability of maintaining flexibility and lead time for shop floor	FLEXILEADTIME
24.	The ability of effective use of learning curves/experience	LEARNCURVE
25.	The percentage of skilled workforce at manufacturing	SKILLMFG
26.	The extent of incremental innovations occurred in process development	INNOVATION
V. Organizational Capability		
27.	The ability of handling multiple R&D/innovation projects parallel	MULTIPROJ
28.	The extent to which coordination and cooperation between R&D, manufacturing and marketing	COORDICOOPER
29.	The ability of high-level integration and control on major functions	FUNCCONTORL
30.	The ability towards developing absorptive capacity and in-house learning	ABSORPTIVE
31.	The ability of effective implementation of organizational routines towards innovation	ORGROUTINES
VI. Marketing Capability		
32.	The ability of relationship management with major customers	CRM
33.	The ability of time to market new products/reduction of new technology development time from concept to market	TIMETOMARKET
34.	The extent of good knowledge about different market segments	MARKETSEGM
35.	The ability of having efficient sales-force/marketing programme	
36.	The ability of excellent after sales services	AFTERSERVICE
VII. Strategic Planning Capability		

37.	The ability of identifying strengths and weakness	STRENTHWEAK
38.	The ability of identifying external opportunity and threats	OPPORTHREAT
39.	The extent of having clear goals	GOALS
40.	The ability of having road map of new product and process with measureable milestones	ROADMAP
41.	The ability of effective resource allocation to all SBU's/STU's	RESOURCES
42.	The ability of highly adapted and responsive to external environment	EXTENVIRON
43.	The extent to which technology strategy adapted in the firm	TECHSTRATEGY
44.	Ability of linking Technology strategy with business strategy	TECHLINKBUSI

Abbreviations: SBU – strategic business units; STU – strategic technology units

4.2 Research Methodology: Sample selection, Data collection and Analysis

Empirical qualitative and quantitative research methodology is adopted to test the hypotheses. In this pilot study, empirical evidences are collected from 35 auto-component supplier firms out of 108 sample firms and the primary 65 responses are analyzed.

4.2.1 Sample Selection:

The Pune auto and auto-component cluster has selected for the study and studycarried out from January 2012 to September 2012. This cluster spread in the Pune-Mumbai-Aurangabad belt of Maharashtra state, India and consists 19 auto firms and 170 auto-component supplier firms (SIAM and ACMA, 2012). Study included interview based and survey based methodology, where total 56 interviews were conducted (auto firms, auto-component firms and support institutions) in three different stages and sample survey of 108 auto-component firms (Large Tier I& II, Medium Tier I & II and small Tier III firms) performed. The first phase was a qualitative study comprising pilot interviews during January 2012 to March 2012 with lead auto firms managers, local SMEs owners, and engineers. The aim of which was to preliminarily understand evolution and development of cluster, benchmark dimensions of cluster and their interaction, technological change agents and innovation capability building process in the cluster.

After a number of pilot interviews (seventeen), we carried out a round of formal interviews during July 2012 (twenty seven) and subsequently in the month of September 2012 (fourteen five) with additional retired experts, R&D personnel, SME engineers and authorities from associated institutions in the cluster, all of whom are experienced engineers and managers with a technology background. The experts were chosen as follows: (1) Engineers and managers those have worked in the cluster for more than ten years; (2) they have rich mobility experiences (trainings, trade fairs and members of associations etc.) within the cluster; (3) local SMEs owners (3) seven experts were from R&D background; (4) five experts were from ARAI Pune, Auto Cluster Project, MCCIA, UNIDO, and UoP respectively. In the second phase of study, we performed a survey on 108 auto-component firms selected from the list of SIAM and ACMA members. We have also collected multiple responses from same firms and computed the averages as the scores used in the analysis to increase the reliability of the data. The total 341 responses were planned to collect, out of which 265 responses are collected from 78 firms in this primary survey. Based on literature and interaction with experts, we have designed the questionnaire.

4.2.2 Data collection and Measurement:

The study questionnaire contained three parts. The first part was about basic information, including the firm's year of establishment, number of employees, and lines of business, as well as respondents' related information (title, job tenure, and years of work experience in the line of business, mobility within cluster). The second part consists ofinnovative sales performance intensity of firm from last three years. It can be calculated as sum of R&D expenditure, import of components and raw material, expenditure on advertisement and sales promotion, foreign expenditure on technology know-how/services, import of capital goods, and Skill by Sales Turnover multiplied by 100. The proxy variable index is provided in Appendix B depending on type of firm. The size of firm gets normalized due to sales turnover. The third part was about the degree of influence/impact of innovation capabilities on innovative performance of firm within Pune auto-cluster. Also, it covers how firm innovation system interacts with cluster innovation system and global value chain to build innovation capabilities. We have asked respondents to answer the question on the basis of 5-point Likertordinal Scale (1= very low, 2 = low, 3 = average/moderate, 4 = high, 5 = very high). The variables measured as percentage coded to ordinal scale of 1, 2, 3, 4, and 5 (0 to 20 – 1, more than 20 up to 40 – 2, more than 40 and up to 60 -3, more than 60 and up to 80 – 4, and more than 80 and up to 100 -5) to have a consistency with other variables.

The auto-component suppliers are classified into cognitive sub-groups like small, medium and large based on number of employees (MSMED, 2006) and generally in Indian automotive industry, there is no size difference between Tier I and TierII large, medium and small firms, and Tier III firms are small and tiny (Uchikawa and Roy, 2010).A multi-level networking structure has been shaped in the relationships among auto-manufacturers and suppliers in clusters. Understanding research focus of the present study, the Pune automotive cluster can be placed into the cognitive subgroups in the cluster as: Large auto-component supplier's subgroup 1 (Tier I and Tier II), Medium auto-component supplier's subgroup 2 (Tier I and Tier II), Small auto-component supplier's subgroup 3 (Tier I, Tier II and Tier III). This highlighted interaction between global value chain perspective and innovation systems perspective and influence on innovation capabilities of firms within cluster.

Firm size was used as a control variable in this study.Previous studies have indicated there could be a positiverelationship between firm size and technological innovation performance as size can affect a firm's innovation and performance. Large firms tend to havemore resources with which to enhance their innovation capabilityand performance. In automotive industry, large firms are usually more powerful than smallcompanies and have some advantages in gaining the support for their business operations and innovation activities. On the other hand, other few studies have revealed that company size has no direct influence ontechnological innovation performance. This study included data from Tier I, Tier II and Tier III auto-component industries, we controlledfor the possibility of industry effects in our analysis by usingdummy variables for the type of industry. This approach was takenbecause firms from different industries may have differing levels ofperformance in innovation capability and efficiency.

4.2.3 Data Analysis

Empirical analysis used a two-stage structural equation model (SEM) to test the theoretical model (Anderson &Gerbing, 1982; Kline, 1998). In the first stage, we developed a measurementmodel and performed confirmatory factor analyses (CFA) to demonstrate the model's psychometric properties of reliability, validity and dimensionality. In the second stage,we tested the hypotheses through covariance structure models. We used the SPSS-AMOSsoftware to estimate structural models, and the maximum likelihood method with robust estimators to estimate the parameters to improve the requirements of normality.

The measurement analysis included assessments of the scale reliability, convergent validity, discriminant validity, and uni-dimensionality of the research constructs. Cronbach's alphawasused to assess the scale reliability of each construct in the research model. Cronbach's alpha for every factor (shown in Appendix B) was greater than the suggested threshold value of 0.7 for an acceptable level of reliability (Kline, 1998). The convergent validity of the research constructs was assessed using exploratory factor analysis (EFA). The EFA results showed that all the constructs had eigenvalues exceeding 1.0 and that all the factor loadings exceeded 0.3 (Appendix B). The convergent validity of the research constructs was therefore confirmed. Discriminant validity and uni-dimensionality were assessed using confirmatory factor analysis (CFA) and the results are shown Appendix C.

The measurement model constructed for CFA had a relative chi-square value of $2.325 < 3$, an incremental fit index (IFI) of $0.946 > 0.9$, and a comparative fit index (CFI) of $0.916 > 0.9$. The standardized loadings (λ) for all constructs were high ($\lambda > 0.5$) and the corresponding t-values were statistically significant. These results indicated uni-dimensionality among the research constructs. A check of the modification indices for the measurement model conducted during the CFA process revealed no significant cross loadings among the variables ($\lambda > 0.85$), which indicated good discriminant validity (Kline, 1998). The scores for valid variable items in each construct were then averaged as a single score to be used in the model analysis.

The hypotheses were tested by way of structural equation modeling (SEM). SEM enables us to test several multiple regression equations at the same time and is therefore a very useful tool for testing overall model fit with a lower degree of measurement error. In the model analysis, maximum likelihood estimation (ML) and standardized regression weighting were used for interpretation. Multiple indices of fit including IFI, CFI, and cmin/df were used to specify the overall model fit. The IFI and CFI values were over 0.9 and that of cmin/df was below 3, indicating a good degree of model fit (Bentler, 1990). An RMSEA value of less than 0.7 indicates an adequate degree of model fit (Bollen, 1989). The research hypotheses were tested according to the significance of the t-test result in each path, with parameter estimates being made in the SEM process.

5. Results and Discussion

Empirical evidence collected in the interviews withlocal suppliers, we identified a pattern in the process ofstrengthening the technological and manufacturing capabilities through theirinteraction with leading firms. *Problem solving*: a local supplier starts a connection with the auto assembleror one of its suppliers by solving operational and unexpectedproblems in the production process, or minor maintenancetasks and adaptations to the facilities. This usually involvesproblems associated with systems compatibility, equipmentfailures, or changes in the assembly line. When a local companyis capable of solving those types of problems, a relationshipof trust is established which will eventually give thelocal company ongoing access to other tasks within the firm.*Trust building*: after the local supplier has proven its willingness and capacityto solve some of the shop floor/factory's operational problems, a moresolid relationship is established and a reputation is built with the decision makers within the leading company and its majorsuppliers. Based on that reputation, the local provider becomesincorporated into the stable supplier pool.*Diversified supplier*: The local company becomes an ongoing supplier of productsor services. Often, these firms manage to diversify theproducts or services they offer to the assembly plant and theirportfolio of other clients within the automotive industry.*Outsourcing of engineering, quality control and maintenance*: Some local companies evolve toward a higher level, becomingan outsourcing partner in areas such as engineering, programming,quality control, design and manufacturing,among other activities. As a result, the local provider becomesfully included in the assembly plant's supply chainand knowledge spillover plays important role to position supplier firms at global value chain.

The empirical results show that firms interact positively with external source of innovation (innovation systems perspective) and knowledge spillover (global value chain) to build innovation capabilities.

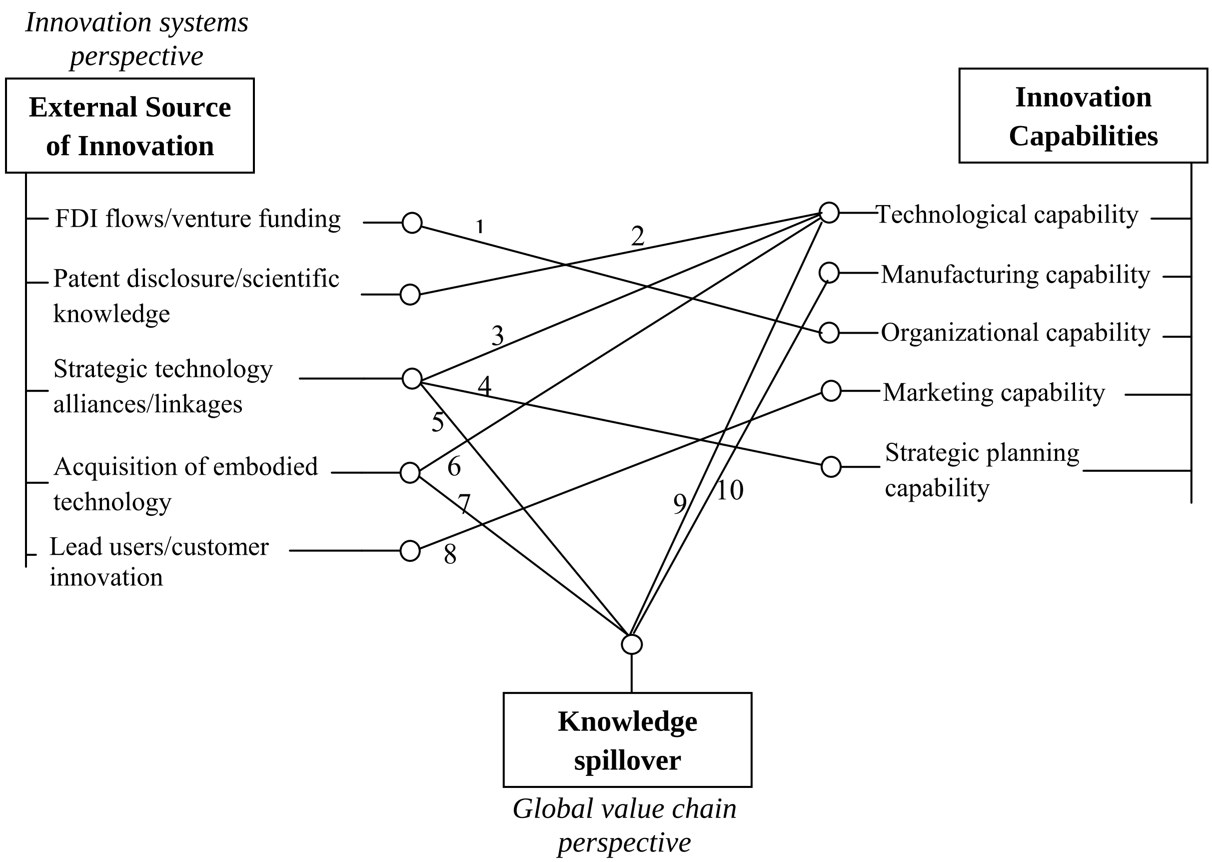

Fig 5.1: Interrelation among macro and micro environment at cluster to build innovation capabilities.

Different links can be identified between the three dimensions of innovation capability building at Pune automotive cluster.Link 1 – In Pune automobile cluster, FDI flows to auto firms and auto-component large Tier I & II companies as well as Venture Funding to medium and small auto-component firms as an external source of innovation has strong influence to build organizational capabilities towards technology acquisition and development.Link 2 –Firms gained R& D capability through better absorptive capacity of scientific knowledge and patent disclosures. Effective technological learning's from codified knowledge plays an important role in building technological capability. Link 3 – Technological capability was mostly affected by strategic technology alliances and linkages within automotive cluster. Indian automotive industry is still a technology follower in few critical components. Link 4 –Technology acquisition has become an important part of organization's technology strategy in order to launch products on time as well as improve efficiency of plant. Link 5 –Technology alliances and linkages has most effective source of knowledge spillover and positioning firms in global value chain. Link 6 – Majority of technological capability influenced by acquisition of embodied technology. Link 7 – Technological acquisition brought knowledge transfer and firms are aligning their R&D capabilities based on this. Link 8 –Marketing capability in automotive sector has been impacted by customer innovations and lead users. Link 9 –Knowledge spillover i.e. tacit as well as codified knowledge transferhas potential in building technological capability in-terms of learning capability and R&D capability. Link 10 – Process innovations in the plant were mostly affected by knowledge spillover though various strategic technology acquisitions enhancing manufacturing capability.

The empirical results performed by structural equation modeling comprise descriptive statistics (means, standard deviation and correlations) and in Fig 5.2 the unidirectional arrows represent the regression relationship between two variables. A good degree of model fit was observed for proposed model by overall fit of indices.The model yielded cmin/df of $1.259 < 3$, CFI of $0.943 > 0.9$, and RMSEA of $0.043 < 0.07$. The study supports research framework by indicating utilization of external sources of innovation in enhancing innovation capabilities and thus it has influence on innovation performance of firms within cluster. The hypothesis testing revealed that all innovation capabilities can be enhanced by external source of innovation and this will not happen without effective utilization of knowledge spillover. Innovation systems perspective positively interacts with innovation capabilities of firm within cluster and also helps to position them into global innovation chain.

Pune automobile cluster (specifically auto-component firms) is still in process of gaining indigenous R&D capability to develop critical components and focus on basic industrial research. Technologically innovative products are normally developed by technology acquisition from developed nations and automation at manufacturing processes observed through active assistance in the cluster. Hence the ability of embodied technology acquisition, patent disclosure/scientific knowledge, strategic technology alliances, knowledge spillover through assistance from domestic and global OEMs, and technology transfer are major source of innovation for Pune automobile cluster.However, effectiveness of the technology and knowledge transfer depends on the competence of people involved and business strategy of the firm (Teece, 1996). The success of firm largely based on its effective learning capability and exploiting the available knowledge. Technological capability is construed as an ongoing process of learning and indicating greater attention to in-house R&D capability building. To some extent mobilization of people and spin-offs specifically from Tata Motors (TELCO then) have played significant role in the region with respect to technology transfer.

Automobile cluster firms are positioning themselves in global value chain and knowledge spillover can act as bridge enabling the firm to improve the effectiveness of its knowledge transfer activities. Result of hypothesis testing shown in Fig 5.2 and indicates that knowledge spillover plays dual role. It has become one of the sources of innovation for effective transfer of knowledge and positively related to manufacturing capability as well as technological capability.

These capabilities of firm were enhanced by formal and informal knowledge transfer, socio-professional and local markets, and technical and managerial support from auto firms. Knowledge spillover has no direct impact on other capabilities of firms. Experts claimed that new problem solving methods have been adapted within cluster due to technology acquisition, strategic technology alliances and support from global OEMs rather than consultancy firm or universities.Hence both external sources of innovation and knowledge spillover externalities has dominant influence on building innovation capabilities of firm within a cluster.

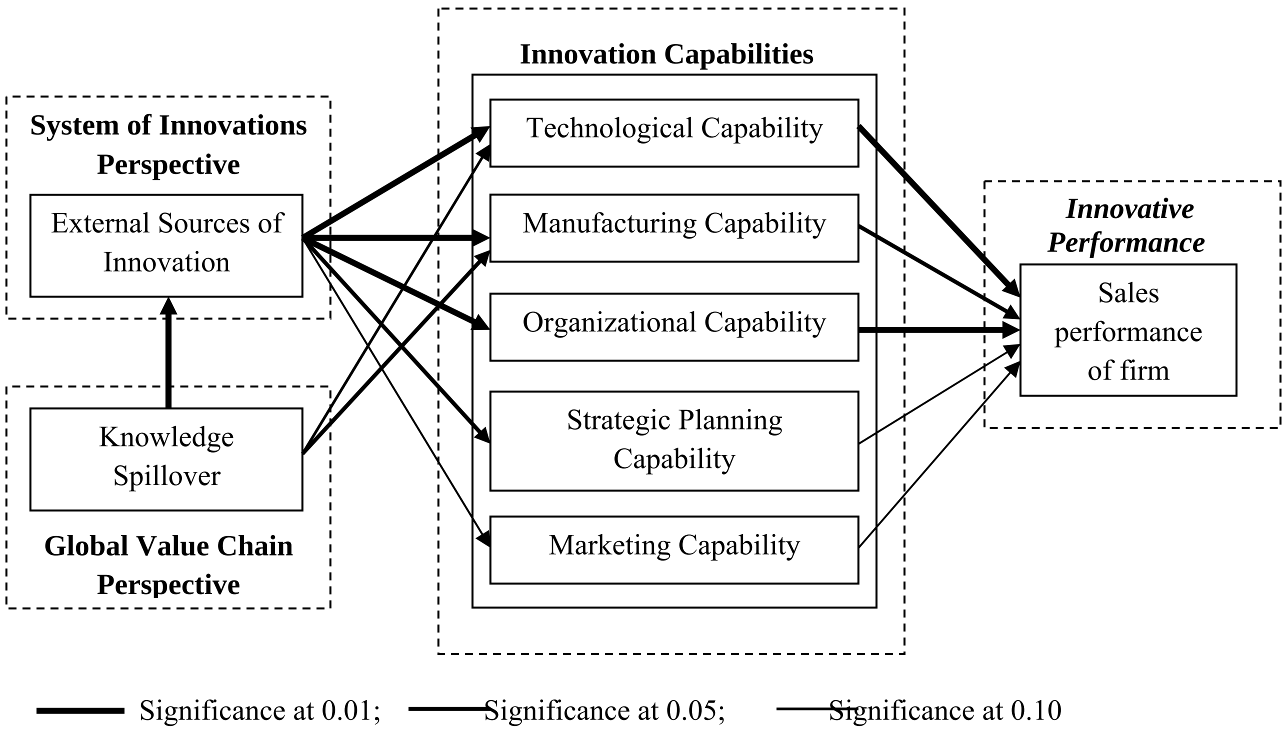

Fig 5.2: Structural Equation Modeling Results for innovative performance of SMEs

Results show that cluster firm's innovation capabilities are enhanced by external sources of innovation and positively related to technological capability, manufacturing capability, organizational capability, marketing capability and strategic planning capability. Most importantly learning capability has positive effect to build technological capability and influence innovative performance of firms. Cohen *et al* (1990) found that an organizational unit's internal learning capability determines the extent to which it can absorb new knowledge from other units.Camison et al (2011) suggested that critical mass of knowledge which gets accumulated by intra-district firm's takes maximum advantage of acquisition, internationalization and application of external knowledge. Thus such capability development by firm is critical for successful innovations. Among all innovation capabilitiesTechnological capability (includes in-house R&D, learning and R&D resource allocation capability), manufacturing and organizational capability most positively related to innovative performance (sales performance) of firm's within Pune automobile cluster. As sales performance measured the percentage of sales generated by technologically new or improved products in last three years, it concerned not only the design and manufacture of new or improved products, but also the production of new or improved products that are marketable. Yam *et al* (2011) has measured technological innovation performance of Hong Kong manufacturing industries and has shown that learning capability has not played significant role to improve sales performance of firm. This study adapted similar approach to measure innovation performance of firm in terms of sales performance.

Innovative performance of firm's within cluster enhanced mainly due to in-house R&D efforts towards product and production process development, extent of technology acquisition, specialized skills and learning orientations. Interestingly large auto-component firms are building ability of manufacturing complex or discrete components and getting active support in product development in few cases.Manufacturing capability has positive effect on performance because of ability of applying advanced manufacturing methods (mostly defined by OEMs), ability to maintain flexibility and lead time at shop floor, effective use of learning/experience curves and incremental innovations. Organization capability also played decisive role in enhancing innovative performance by developing ability of firm transforming R&D and design output into production and extent of coordination among departments like manufacturing, marketing and R&D within organization. Large auto-component firms are engaged into developing organizational routines for innovation and better absorptive capacity development. Moreover, experts asserted that overall sales performance of firm has an impact of marketing but our hypothesis testing result of innovative performance of firm has not strongly supported this argument. This is mainly because, automobile OEMs are more focused on performance characteristics of auto-components and timely delivery.

6. Conclusion

This study has contributed towards theoretical and practical aspects. The growing attention of global value chain perspective and innovation systems perspective in automobile industry and their interaction with firm innovation capability within a cluster to measure innovation performance has not been fully investigated in earlier studies empirically in emerging economy like India. The external sources of innovation and better utilization of knowledge spillover activities has strong interrelatedness to build various capabilities of firms.The study confirms dual role of knowledge spillover as a source of innovation for effective knowledge transfer and influence on technological and manufacturing capability. Regional innovation system and firm innovation system interacts positively. Our results have shown that external sources of innovation have positively related to enhance all innovation capabilities of firms within cluster. Among all innovation capabilities Technological capability (includes in-house R&D, learning and R&D resource allocation capability), manufacturing and organizational capability most positively related to innovative performance of firm's within Pune automobile cluster. The study has limitation that a bigger sample size may have produced more statistically accurate results in the model testing process though overall model fit has accounted.

Notes

1. Absorptive capacity: A limit to the rate or quantity of scientific or technological information that firm can absorb. If such limits exist they provide one explanation for firms to develop internal R&D capacities. R&D departments can not only conduct development along lines they are already familiar

with, but they have formal training and external professional connections that make it possible for them to evaluate and incorporate externally generated technical knowledge into the firm /…/. In other words, a partial explanation for R&D investments by firms is to work around the absorptive capacity constraint. (Cohen and Levinthal 1990).

2. Bergman (2008) proposed cluster life cycle model based on Utterback and Abernathy's (1975) technology life cycle model and Klepper's (1996) industry life cycle model: emergence, growth, sustenance and decline.
3. Homologation: It means ensuring through tests whether vehicle produced out of manufacturing facility meets the safety and environment stipulation of country in which it is sold.

Appendix A: Definitions and concepts

Clusters are geographical concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions (universities, standards agencies, trade associations) in a particular field or related fields that compete but also co-operate (Porter 1998).

Technological capability is the ability to make effective use of technological knowledge in production, engineering, and innovation in order to sustain competitiveness in price and quality (Kim, 2001). Lall (1999) define technological capability in industry as the skills – technical and organizational – that are necessary for enterprises to set up a plant, utilize it efficiently, improve and expand it over period of time, and develop new products and processes. Learning and R&D efforts are construed in the technology capability

Learning capability is the firm’s ability to identify, assimilate, and exploit knowledge from the environment.

R&D capability refers to the firm’s ability to integrate R&D strategy, project implementation, project portfolio management, and R&D expenditure. Resources allocation ensures that the firm possesses enough capital, professionals and technology in the innovation process.

Manufacturing capability refers to the firm’s ability to transform R&D results into products, which meet market needs, accord with design request and can be manufactured in batches.

Organizing capability refers to the firm’s ability in securing organizational mechanism and harmony, cultivating organization culture, and adopting good management practices.

Strategic planning capability is the firm’s ability to identify internal strengths and weaknesses and external opportunities and threats, formulate plans in accordance with corporate vision and missions, and acclimatize the plans to implementation.

Marketing capability is the firm’s ability to publicize and sell the products on the basis of understanding consumer needs, competition situation, costs and benefits, and the acceptance of the innovation.

Appendix B: Details of Proxy variables

Table B1: Proxy Variables for Innovative Sales Performance intensity based on type of automobile and auto-component firm within Pune auto-cluster

Sr. no	***Auto-firm***	***Auto-component firms***		
		Tier I& Tier II (large)	***Tier I and Tier II (Medium)***	***Tier I & Tier II &Tier III (Small)***
1.	Sales Turnover	Sales Turnover	Sales Turnover	Sales Turnover

2.	R&D expenditure	R&D expenditure or Product development & engineering expenditure	Semi Product development and design expenditure Quality control expenditure	Quality control expenditure
3.	Import of components and Raw materials	Import of raw material and sub-components	Expenditure on raw material	Expenditure on raw material
4.	Expenditure on Advertisement & sales promotion	Expenditure on advertisement & sales promotion	Marketing expenses	Tendering and marketing expenses
5.	Foreign expenditure on technology know-how/services	Technology Know-how and consultancy fees	Technology support and consultancy fees	Technology purchasing and support fees
6.	Import of capital goods	Import and expenditure on equipment & machinery	Expenditure on equipment & machinery	Expenditure on machinery
7.	Specialized Skills (Salaries & wages + trainings)	Skilled manpower + training & development	Skilled workforce	Labor & supervisor's salaries and wages

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