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A TISM modeling of Critical Success Factors of smartphone manufacturing ecosystem in India

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1. Introduction

The telecommunications industry is one of the most rapidly growing industries in the world. The telecom sector in India has exhibited remarkable growth in the past few years, and this has made India's telecommunication network the second-largest in the world after China (Ghosh et al., 2014). One of the major reasons that has led to the prodigious growth of this industry is the swift change in information and communication technology over the past few years. The number of telephone connections in India reached 971.01 million in 2014 and includes approximately 944.01 million wireless connections, which makes 97.22%, share of the total telephones (Department of Telecommunications (GoI), 2014).

At present, smartphones are represented as the fastest growing market segment in the telecom industry. The sales of smartphones have grown globally by 26% in 2015 and have captured more than half of the telecom market in the world (Cecere, 2015). Based on the processing capabilities and supporting characteristics, smartphones are defined as a class of electronic devices that incorporate multiple computing capabilities into the basic form of a cellular phone. It has become the chosen device around which governance, commerce, education and tele-medicine initiatives depend. The smartphone ecosystem of the telecom sector consists of following key components (Figure 1):

- Customers who purchase smartphones from device vendors.
- Content providers from whom a variety of movies, music and other contents can be downloaded and purchased.
- Application developers who provide various utility software.
- Service providers who deliver voice/data connectivity and mobility and also offer extra services such as e-mail and SMS.
- Device makers, who supply smartphones to vendors.
- Operating system (OS) owners who give license of OS to the device makers and in turn device makers certify the application from the developers.
- Platform makers who act as a content aggregators and application distributors (Lin et al., 2009).

<<INSERT FIGURE 1 ABOUT HERE>>

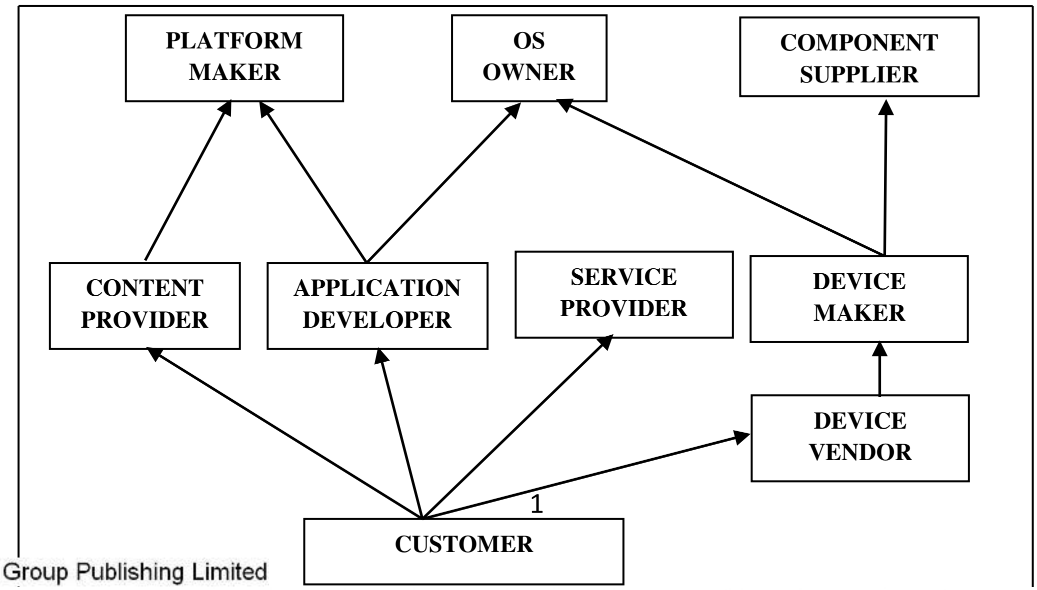


Figure 1. Smartphone Ecosystem (Modified from Lin et al., 2009)

It is evident that none of the individual components of the smartphone ecosystem can work effectively unless all other components are performing well. The basic framework for the value chain of any smartphone manufacturing in India has been presented in Figure 2 which illustrates the various components required to manufacture a smartphone.

<<INSERT FIGURE 2 ABOUT HERE>>

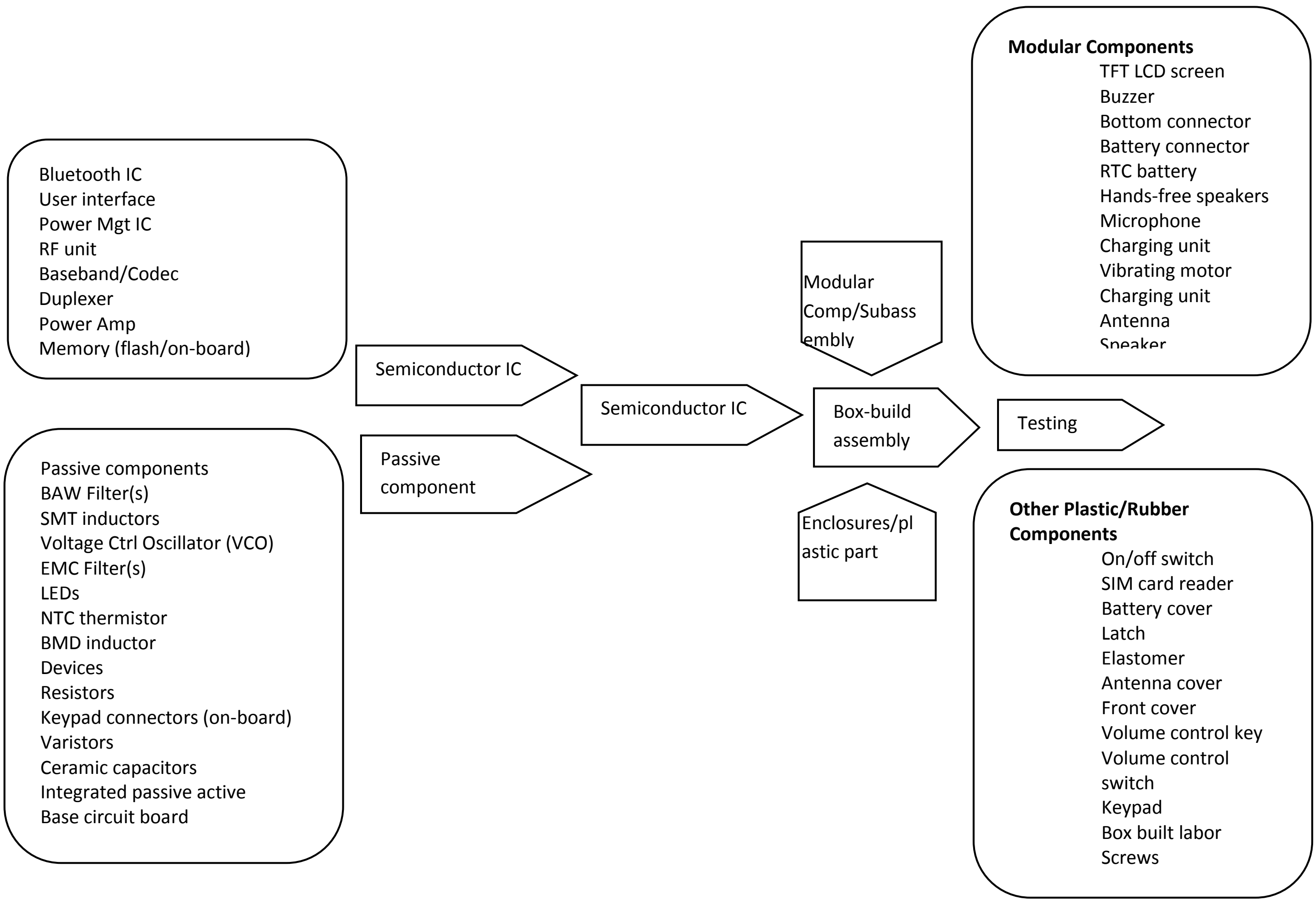


Figure 2. Value Chain Entities (Source: Modified from Sen, 2012)

With the advent of next-generation technologies and operators rolling out 4G, the demand for smartphone manufacturing has been increasing rapidly. Conversely, the Indian telecom sector is plagued with a lack of industries for smartphone manufacturing. This is due to many factors such as the high consumption of mainly voice services compared to data services, availability of cheaper products, especially those manufactured in China, fierce market competition and a lack of semiconductor wafer fabrication units (Department of Telecommunications (GoI), 2013).

Consequently, there is a need for a systemic approach to evaluate and study key CSFs that can enable smartphone manufacturing in India. In view of the importance of this need, the paper attempts to develop an inter-relationship framework of a smartphone manufacturing ecosystem. In this paper 15 CSFs have been identified through literature and brainstorming with experts from industry and academia. For analyzing inter-relationships among these enablers TISM and MICMAC analysis have been used.

The main objectives of this paper are as follows:

- To identify the critical success factors of the smartphone manufacturing ecosystem in the Indian industrial environment.
- To establish mutual relationships, relative importance and interdependence of each critical success factor.
- To analyze the driving and dependence power of the factors affecting the smartphone manufacturing system.

The paper is further organised as follows. We first identify various CSFs through a literature review and discussions with experts. An overview and the use of the TISM technique and MICMAC analysis for modelling CSFs of the smartphone manufacturing ecosystem have been presented next. The model is analyzed and interpreted in the following section. Finally, conclusions and future scope of research are discussed at the end of this paper.

2. Literature Review

Based on the literature review and discussions with the industry experts and academics, a total of 15 CSFs have been identified that help in the development of the smartphone manufacturing ecosystem in India. These are discussed as follows.

2.1 Large Consumer Base

A consumer base consists of a group of customers who are demographically differentiated in terms of the usage of smartphones. This is comprised of a group of customers who are actually using the smartphone and, therefore, can be called handset owners. A large consumer-base indicates that potential customers in the market have actually purchased the smartphone and are utilizing it in their day-to-day life. According to Dixit et al. (2011), the ownership of smartphones is exponentially growing among different types of customers such as professionals, students and general consumers. Woodcock et al. (2012) conducted a collaborative study to understand the extent to which students are using smartphone technology to support their learning and knowledge base. Martensen (2007) examined the satisfaction and loyalty of tweens (8-12-year-olds) to their mobile phones. In another study conducted by Fortunati (2002), it was observed that the smartphone has not only changed society but also transformed the framework in which society lives. In India, there is still a segment of the population, mainly in rural areas, that do not own a handset and a small fragment of urban population also do not own a phone. Hence, there are many potential buyers for smartphones in India.

2.2 Government and Legislative Support

The government and legislative support in India has been moderate to low. This has been hindered by the manufacturing of smartphones in India to a large extent (Sridhar, 2012). On the other hand, China followed policies that promotes local manufacturing. Some of its policies include compulsory licensing for local manufacturers, attractive incentives for electronics manufacturing and effective VAT of 6% on locally manufactured phones, vis-a-vis 17% VAT on imported phones (Wauschkuhn, 2001). Only recently (post-2015), has there been an attempt by the Government of India to focus on manufacturing under the bigger umbrella of the 'Make in India' initiative. According to the Department of Telecommunications (2015), the Government of India has started taking initiatives to develop a manufacturing ecosystem in the telecom domain. The Indian government has also imposed R&D tax on imported electronic products to differentiate between domestically produced goods and imported goods (Deloitte, 2013).

2.3 Trained Manpower

The telecommunication industry in India comprises of both semi-skilled and highly talented human resources. Different types of trainings have been provided to these resources to suit industry requirements. According to a report by the Department of Telecommunications (2015), various training programs on different areas of telecommunications have been conducted every year. In another study conducted by Deloitte (2013), talent-driven innovations have been considered to be the most important driver to increase the country's competitiveness in the manufacturing sector. This will further help in positioning India as one of the paramount smartphone manufacturing hubs in the world.

2.4 Foreign Direct Investment

Foreign Direct Investment (FDI) is a direct investment into a business in one country by a company established in another country. India has been considered the second most preferred FDI destination after China (Deloitte, 2013). This is an important factor in the development of a smartphone manufacturing ecosystem in the country as FDI will help fund new innovations and technologies. According to a report published by the Department of Telecommunications (2015), the Indian government has raised the FDI limit from 74% to 100% in the telecom sector. Some of the reasons for FDI include the availability of semi-skilled and cheap labour and close access to ports and airports (Sahiti, 2013). FDI in many other neighbouring countries of India, such as Pakistan, has increased continuously from 2003 to 2012, especially in the telecom sector (Imtiaz et al., 2015).

2.5 R&D Funding

Research and development (R&D) needs to be focused on by India if the country wants to succeed as a smartphone manufacturing hub. Tripathi et al. (2012) have discussed the importance of R&D in manufacturing firms. According to them, no research can be done without financial support, which has to come from the government and the private sector, including FDI. Most global companies take up R&D in their own country and this generates many opportunities for the local companies as well as the educational institutions to focus on R&D (Hu and Hsu, 2008). At present, India lacks global-scale companies to promote R&D.

To bridge this gap, the Indian government has taken up various initiatives. According to the Indian National Telecom Policy (2012), early stage angel and venture funds will facilitate the telecom manufacturing sector and promote innovation and R&D within the country (DoT, 2013). Furthermore, there are many factors that might attract R&D funding, including presence of R&D houses of MNCs and highly reputed educational institutions, which have young talent that can be utilized efficiently in an ever-growing market.

2.6 Innovation and Technological Know-How

Technological developments have led to digitalization, which in turn have converged different types of media into a single device (Wauschkuhn, 2001). Innovation comprises of two components, namely, invention and commercialization. Innovation not only signifies developing or improving new technologies but it also encompasses commercialization. Fan (2006) discovered that innovation and self-developed technologies have increased the competitiveness of the domestic firms. The author has also analyzed the strong relationship between leaders of the telecom-equipment industry and innovation capacity. India would need the latest technologies so that various components of the smartphone can be manufactured in a cost-effective manner. In addition, new innovations need to be created to support and improve the existing technology and devices, such as adding new applications (Schumpeter, 1942). Micromax is one of the domestic manufacturers of smartphones in India which has gained success in the market in a short span of four years. It is considered an Indian innovator as it has many 'firsts' in the market such as 30-day battery backup, dual-sim handset and handset switching networks (Ahmed, 2012). The first thing users demand before purchasing the smartphones is the features of the handset such as quality of the camera, size of the phone and metal accents (Biswas, 2013). Gawer and Cusumano (2014) have dealt with issues such as how to manage innovation within and outside the organization while studying the ecosystem for mobile computing and communication platforms.

2.7 Physical Infrastructure

Physical infrastructure includes quality and efficiency of the IT and telecommunications networks, roads, airports, ports and railroad networks. It has been considered one of the most important drivers of manufacturing competitiveness (Deloitte, 2013) and has attracted FDI and, in turn, boosts the job availability in the market and fosters a growth cycle. It further impacts efficiency and performance of a manufacturing unit (Sekkat and Varoudakis, 2007). China has invested hugely in the infrastructure that led to the enhanced pace of reforms in the telecom sector and helped it to move out of the stagnant growth phase (Wauschkuhn, 2001).

2.8 Product Design

The aim of product design in a company is to examine the features of smartphones that will impact users' emotional reactions and preferences towards the product. Contrary to innovation and technical know-how, it involves only technological aspects for manufacturing the smartphones. At the time of designing the product, various hardware and software are integrated and it also involves the integration of creativity with the existing technology, keeping in mind customer requirements (Nanda et al., 2008). For example, ZTE collaborated with Italian designer Stefano Giovannoni to develop a Nubia phablet, which is a 'super' smartphone closer to the size of tablet (Wagstaff and Yee, 2013) and takes into account different activities of the company, such as product quality, price, promotion, placement and product development. Product design helps the company make strategically correct decisions that will help to develop the present as well as the future market in the country. For example, increased focus of government and customers on reducing e-waste has compelled the manufacturers to design smartphones which are relatively more eco-friendly (Wu et al., 2008; Yu et al., 2010; Bhuie, 2004).

2.9 Large Handset Market Potential

The large handset market has shown the existence of customers that purchase smartphones, yet the product's penetration in the market is far from complete. This means that the Indian population has the purchasing capability for smartphone but its actual usage is far lower. India has an enormously large population and has a huge untapped market, comprising mainly of rural and semi-urban areas (Thambala, 2014; Sarda et al., 2013). In emerging countries such as India, people have the potential to purchase smartphones due to growing average household income and Indian handset owners are increasing due to cheaper call rates and handsets and widespread availability of prepaid recharges (Sridhar, 2012). India has now entered into a phase where the interest of the people is shifting from a mere cell phone with limited features to smartphones (Kenny and Pon, 2011) and the 3G services in the country have further accelerated the growth of domestic demand for smartphones (Gupta, 2015).

2.10 Global Competitiveness

At present, organizations are competing with each other globally and competition and adoption of a single standard increases the penetration rate among users (Gruber and Verboren, 2001). Access to global customers has increased through the enhanced communications and improved shipping channels (Asai, 2010). Most products today are global and involve services from multiple countries. For example, typical mobile phone components may be from countries like Japan and Korea, which are assembled in China by a company from Finland. In 2012, Samsung had the largest global market share of 23.4% followed by Nokia and Apple with 19.3% and 7.8% market share, respectively (Cecere et al., 2015). The economic conditions in these countries may affect the price or productivity therefore, products need to be produced in such a way that it can compete in global market (Chen and Hu, 2008).

2.11 Supplier Network

A supplier network is a pattern of temporal and spatial processes, carried out at facility nodes and over distribution links. These networks add value to the products through manufacturing and distribution to the end-users. Dittrich and Duysters (2007) assessed the impact of networking as a means of strategy in the case of the telecommunication industry. It comprises of the general state of business affairs, where all kinds of materials are transformed and moved between various value-added points to maximize the value for customers (Deloitte, 2013). Moreover, outsourcing has become a major telecom industrial trend used to improve the competitive advantage of companies and requires a strong supply chain network. Many companies including

Ericsson and Nokia are developing strategies to outsource their manufacturing capabilities (Berggren and Bengtsson, 2004).

2.12 Growing Data Usage

Once the product has been conceptualized and designed, it has to be manufactured and introduced into the market. With the early launching of 4G in India, the demand for smartphones has been rapidly increasing. Data usage is also continuously increasing, which will further innovate smarter technologies for various applications, such as video streaming without buffering or faster downloading of full length movies in less time (Muvva et al., 2012; Mariappan, 2015). The consumers demand that smartphones have greater compatibilities with their requirements along with the new innovations in the product (Kumar, 2013). The upsurge in the use of mobile data services is one of the indicators used to assess the growth in the market share of telecommunication service providers (West and Mace, 2010). Europe and the US have invested multi-billion dollar in third generation mobile phone networks that will deliver DSL-caliber bandwidth to mobile phones at various places (Bekkers, 2001; Ure, 2003). India needs to develop facilities and channelize resources for the same (Hazlett, 2011).

2.13 Application Store specific to Indian Requirements

Convergence of mobile telephony and Internet services have led to the emergence of mobile computing as a new field in the telecom industry (Ishii, 2004). The emergence of application stores has dynamically altered the mobile value chain such as operators, developers, manufacturers and operating system platform owners (Xia and Holmquist, 2002; Koch and Kerschbaum, 2014). Kenny and Pon (2011) analyzed the actions and strategies that were adopted by four major competitors, i.e. Apple, Google, Microsoft and Nokia, through a framework based on technological platform theory. Japanese telecom firms failed to capture the global market share as they did not recognize the importance of software and its ability to allow the users to upgrade their smartphones (Tokunaga, 2013). Once the product has been manufactured, applications can be innovated to suit Indian requirements. For example, there is a large number of Indians with limited understanding of the English language. Therefore, applications that operate in regional languages can be developed with minimal changes to the hardware (Carleen et al., 2005).

2.14 Growth in Export Market

Exporting the manufactured products expands the firm's operations in the international markets, which lack resources or skills required to produce the products (Dalli, 1995). Exporting aids a new venture to enter into foreign markets, gain the international experience and accumulate the resources as well as capabilities to prepare global strategies (Root, 1994).Smartphones or their components manufactured in a country can be first consumed within the country and later can be exported to foreign markets. This will not only generate revenues for any telecom company in India but it will further strengthen the development of smartphone ecosystem in the country (Ahmed, 2012).

2.15 Customer Willingness to Pay

The advent of services such as 3G/4G and bundled packages that contain free minutes of usage, unlimited text messaging, flat Internet rates and the innovative design of smartphone devices have led the customer to purchase the products (Klein and Jakopin, 2014). Once customers get the latest technology at an affordable price along with new features, they develop an intention to purchase the product. Furthermore, improved quality in a product increases their willingness to pay for the products and services offered (Woodcock, 2012). For instance, by raising an awareness of potential customers towards sustainability, their willingness to pay for green and sustainable products would increase (Mohrenfels and Klapper, 2012).

3. Research methodology

The study has been conducted in three steps:

(i) Identification of CSFs through comprehensive review of literature

A preliminary set of 15 CSFs have been identified from the literature. These CSFs have already been discussed in the preceding section.

(*ii) Prioritization and modeling of CSFs using TISM*

The fundamental phase of an organizational research is to develop a conceptual framework from the exploratory study. In the course of developing a conceptual framework, it is necessary to put forth some basic research questions using what, how and why as a basis (Whetten, 1989). This paper has conducted an exploratory study to develop a hierarchical framework for the smartphone manufacturing ecosystem. The CSFs identified earlier constitute the basic elements of this framework. In this phase, relationships among the identified CSFs have been delineated. Further linkages and relationships established among the CSFs in this phase will be interpreted.

An Interpretive Structural Model (ISM) is an influential tool that converts a weakly articulated mental model into a visible and a well-defined model (Sushil, 2005a). It is an interactive learning process and improves the sequence as well as the direction of any relationships among factors. It develops a graphical picture for a particular system of a field under study and helps in determining critical areas to be focused on (Talib et al., 2011). There are two limitations of ISM that should be overcome while conceptualizing the field of the study. ISM only identifies the direct relationship among factors and does not elucidate the indirect relationships existing among factors. Also, it does not explain in what way factor A will help in achieving factor B (Yadav and Sushil, 2013). This paper has attempted to employ Total Interpretive Structural Modeling (TISM), an extension of ISM, in order to overcome above-mentioned limitations of ISM. TISM interprets relationships among factors, which are applicable in real life situations (Sushil, 2012).

In recent years, TISM has been widely studied in various fields. Dubey et al. (2015) applied TISM methodology to understand green supply chain by identifying enablers related to the field of study. Jayalaxmi and Pramod (2015) have used the TISM to develop the performance model for the enablers of the flexible control system for industry and Sandbhor and Botre (2014) utilized this technique to study the factors affecting construction labour productivity. Srivastava and Sushil (2014) developed a framework using TISM in the context of strategy execution while Sagar et al. (2013) found the application of TISM in cloud computing and explored the relationships among the factors affecting the customer defection rate in cloud computing in the context of customer loyalty. Yadav and Sushil (2013) developed a model for strategic performance management for Indian telecom service providers.

The TISM methodology follows a systematic procedure. Various steps involved in the TISM technique are diagrammatically depicted in Figure 3.

<<INSERT FIGURE 3 ABOUT HERE>>

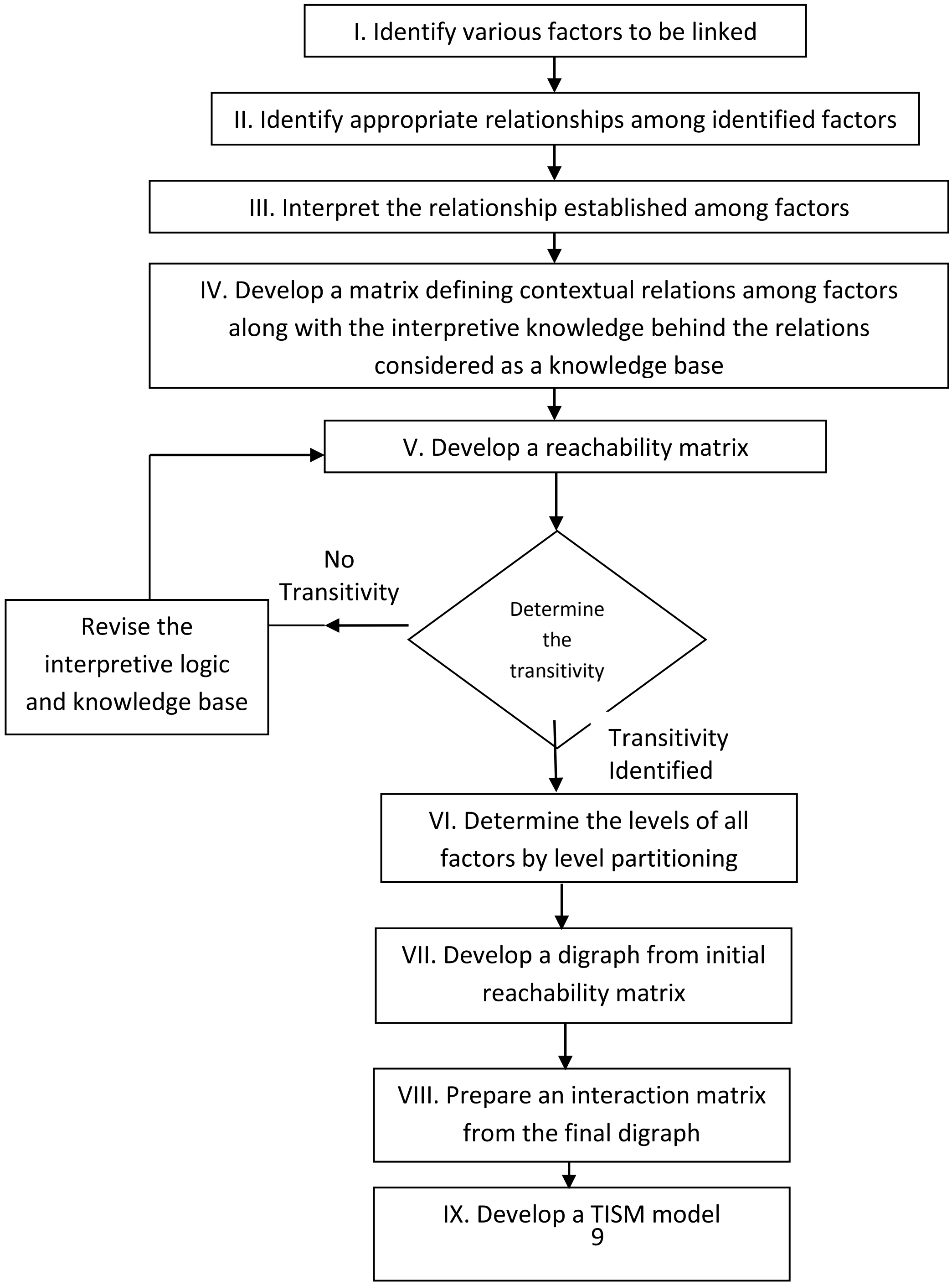


Figure 3. Basic steps involved in TISM (Modified from Sushil, 2005)

Step I: Identify the factors to be linked

The CSFs for developing a smartphone manufacturing ecosystem in the Indian context have already been identified and discussed in the previous sections.

Step II: Identify the relationships between the variables

The relationships among identified factors have been established by understanding whether a particular CSF is influencing or enhancing all other CSFs.

Step III: Interpretation of relationship

The experts had been asked to compare each CSF against the other CSFs. From 15 identified CSFs, a total of 210 comparisons were made. For each comparison, an entry of 'Y' has been made indicating 'Yes' if relationship exists between factors or an entry of 'N' has been made indicating 'No' if there is no relationship between them. While making pair-wise comparisons, an interpretive query for each 'Y' with the question 'in what way the CSF-A is influencing or enhancing CSF-B' has been made and answered by the experts.

Step IV: Interpretive Logic-Knowledge base

The TISM pair-wise comparison is done in which each element is individually compared with all other elements. An 'Interpretive Logic-Knowledge base' has been developed for the identified CSFs. For each pair-wise comparison, an expert opinion is represented either by entry 'Y' indicating 'Yes' or 'N' indicating 'No'. If the entry is 'Y', it is further interpreted by the experts to understand the reasoning behind the relationship between two factors. The responses of experts have been used to develop an interpretive logic knowledge base.

Step V: Development of Reachability Matrix

The interpretations of the identified relationship established in Step III have been used as a basis to form reachability matrix. It is obtained by entering 1 or 0 in the *i-j* cell of the matrix (where *i* is row and *j* is column) in place of 'Y' or 'N', respectively. Then the matrix is tested for transitivity. Transitivity exists if an indirect relationship exists among factors which means if factor *A* leads to factor *B* and factor *B* leads to factor *C*, then factor *A* will also leads to factor *C*. By inserting transitivity in the reachability matrix, a final reachability matrix has been obtained (as shown in Table I). Adding transitivity in the initial reachability matrix is an iterative process.

For each transitivity link, the initial reachability matrix has been updated and ‘N’ entry has been altered to ‘Y’ entry. Finally, ‘transitive’ has been written in the interpretation column.

<<INSERT TABLE I ABOUT HERE>>

Table I. Final Reachability Matrix for Critical Success Factors

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Driving Power**
1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	**3**
2	1	1	1	1	1	1	1	1*	1	1*	1*	1*	1*	1*	1*	**15**
3	1*	0	1	0	0	0	1	0	1*	0	0	1*	1*	1*	1*	**8**
4	1*	0	1*	1	1	0	1*	1*	1*	0	1*	1*	1*	1*	1*	**12**
5	1*	0	1*	1	1	0	1*	1	1*	0	1*	1*	1*	1*	1*	**12**
6	1*	1	1*	1*	1	1	1*	1	1*	1	1*	1*	1*	1*	1*	**15**
7	1*	0	1	0	0	0	1	0	1*	0	0	1*	1	1*	1*	**8**
8	1*	0	1*	1*	1	0	1*	1	1*	0	1	1*	1	1*	1*	**12**
9	1*	0	0	0	0	0	0	0	1	0	0	1	0	1*	0	**4**
10	1*	1*	1*	1*	1*	1	1*	1*	1*	1	1*	1*	1*	1*	1*	**15**
11	1*	0	1*	1*	1*	0	1*	1	1*	0	1	1*	1*	1*	1*	**12**
12	1	0	0	0	0	0	0	0	0	0	0	1	0	1*	0	**3**
13	1*	0	1*	0	0	0	1	0	1	0	0	1*	1	1*	1	**8**
14	1	0	0	0	0	0	0	0	0	0	0	1*	0	1	0	**3**
15	1	0	1*	0	0	0	1*	0	1	0	0	1*	1	1*	1	**8**
	15	**3**	**11**	**7**	**7**	**3**	**11**	**7**	**12**	**3**	**7**	**15**	**11**	**15**	**11**	

* Represents the transitivity links between the factors.

Step VI: Level Partitions of reachability matrix

The procedure of level partition in TISM is similar to the one used in ISM (Kumar et al., 2009). The reachability set and the antecedent set have been identified for each CSF from the initial reachability matrix. When both the intersection set and the antecedent set are similar, a level has been assigned to each CSF. Once the level is allocated to a factor, it is not considered in the next iteration. This procedure is repeated until levels of all the CSFs have been identified as shown in Table II and Table III.

<<INSERT TABLE II ABOUT HERE>>

<<INSERT TABLE III ABOUT HERE>>

Table II. Iteration 1

CSF	Reachability Set	Antecedent Set	Intersection	Level
1	{1,12,14}	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{1,12,14}	I
2	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{2,6,10}	{2,6,10}	
3	{1,3,7,9,12,13,14,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	
4	{1,3,4,5,7,8,9,11,12,13,14,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	
5	{1,3,4,5,7,8,9,11,12,13,14,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	
6	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{2,6,10}	{2,6,10}	
7	{1,3,7,9,12,13,14,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	
8	{1,3,4,5,7,8,9,11,12,13,14,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	
9	{1,9,12,14}	{2,3,4,5,6,7,8,9,10,11,13,15}	{9}	
10	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{2,6,10}	{2,6,10}	
11	{1,3,4,5,7,8,9,11,12,13,14,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	
12	{1,12,14}	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{1,12,14}	I
13	{1,3,7,9,12,13,14,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	
14	{1,12,14}	{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15}	{1,12,14}	I
15	{1,3,7,9,12,13,14,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	

Table III Iteration 2-5

CSF	Reachability Set	Antecedent Set	Intersection	Level
2	{2,3,4,5,6,7,8,9,10,11,13,15}	{2,6,10}	{2,6,10}	V
3	{3,7,9,13,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	III
4	{3,4,5,7,8,9,11,13,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	IV
5	{3,4,5,7,8,9,11,13,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	IV
6	{2,3,4,5,6,7,8,9,10,11,13,15}	{2,6,10}	{2,6,10}	V
7	{3,7,9,13,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	III
8	{3,4,5,7,8,9,11,13,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	IV
9	{9}	{2,3,4,5,6,7,8,9,10,11,13,15}	{9}	II
10	{2,3,4,5,6,7,8,9,10,11,13,15}	{2,6,10}	{2,6,10}	V
11	{3,4,5,7,8,9,11,13,15}	{2,4,5,6,8,10,11}	{4,5,8,11}	IV
13	{3,7,9,13,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	III
15	{3,7,9,13,15}	{2,3,4,5,6,7,8,10,11,13,15}	{3,7,13,15}	III

Step VII: Construction of Digraph

A digraph generally consists of nodes and arrows. Each node represents CSFs and each arrow represents direction of relationships between two factors. Each factor is arranged in the digraph as per the level obtained during level partitioning. The directions of relationships have been established as per the reachability matrix. Indirect relationships have also been shown in the final digraph with the dotted line.

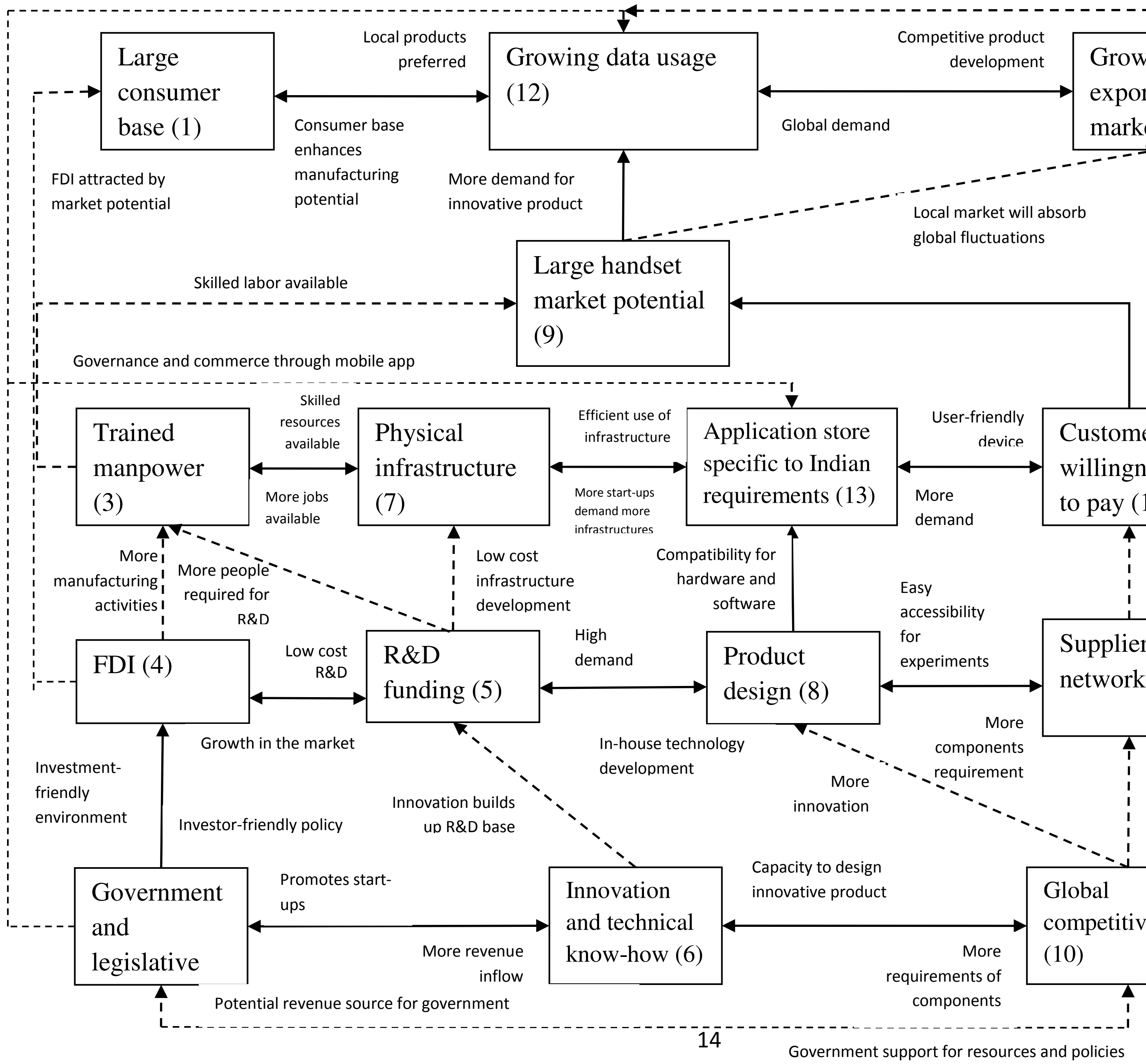
Step VIII: Interpretive matrix

A binary matrix has been developed from the digraph. In this matrix, '1' indicates direct as well as transitive links between factors. Significant relationships among factors are then mentioned in the matrix by using the interpretation provided in the interpretive logic-knowledge base table. The interpretive matrix related to TISM for the smartphone manufacturing ecosystem has been exhibited in the Appendix 1.

Step IX: Formation of TISM- based model

In the final step, a Total Interpretive Structural Model (TISM)-based framework has been developed using digraph and interpretive matrix as shown in Figure 4. In this framework, the interpretation of each relationship has been mentioned. This framework clearly comprehends the driving power as well as the dependence power of each factor necessary to develop a smartphone manufacturing ecosystem in India.

<<INSERT FIGURE 4 ABOUT HERE>>



TISM of Critical Success Factors of Smartphone Manufacturing Ecosystem *(iii) Graphical representation of driving and dependence power of each CSF*

In order to classify CSFs, the driving and dependence power of these factors have been derived from the final reachability matrix. The driving and dependence power of each CSF are then represented graphically using the MICMAC analysis as shown in Figure 5. The y-axis in the graph represents the driving power of the CSFs whereas the x-axis in the graph represents the dependence power of the CSFs. The graph has been divided into four clusters, namely A, B, C and D. The factors in the first Cluster A represent autonomous factors. Any factor, if present in the Cluster A, indicates that it is not linked to other factors and is more or less independent in the system. Factors in the second Cluster B are influenced by other factors and do not influence other factors. Thus, such factors are known as dependent factors. Factors in Cluster C are known as linkage factors. These factors act as a connecting link among factors in the system. Factors in Cluster D are known as independent factors as they drive other factors and are not influenced by other factors in the system.

<<INSERT FIGURE 5 ABOUT HERE>>

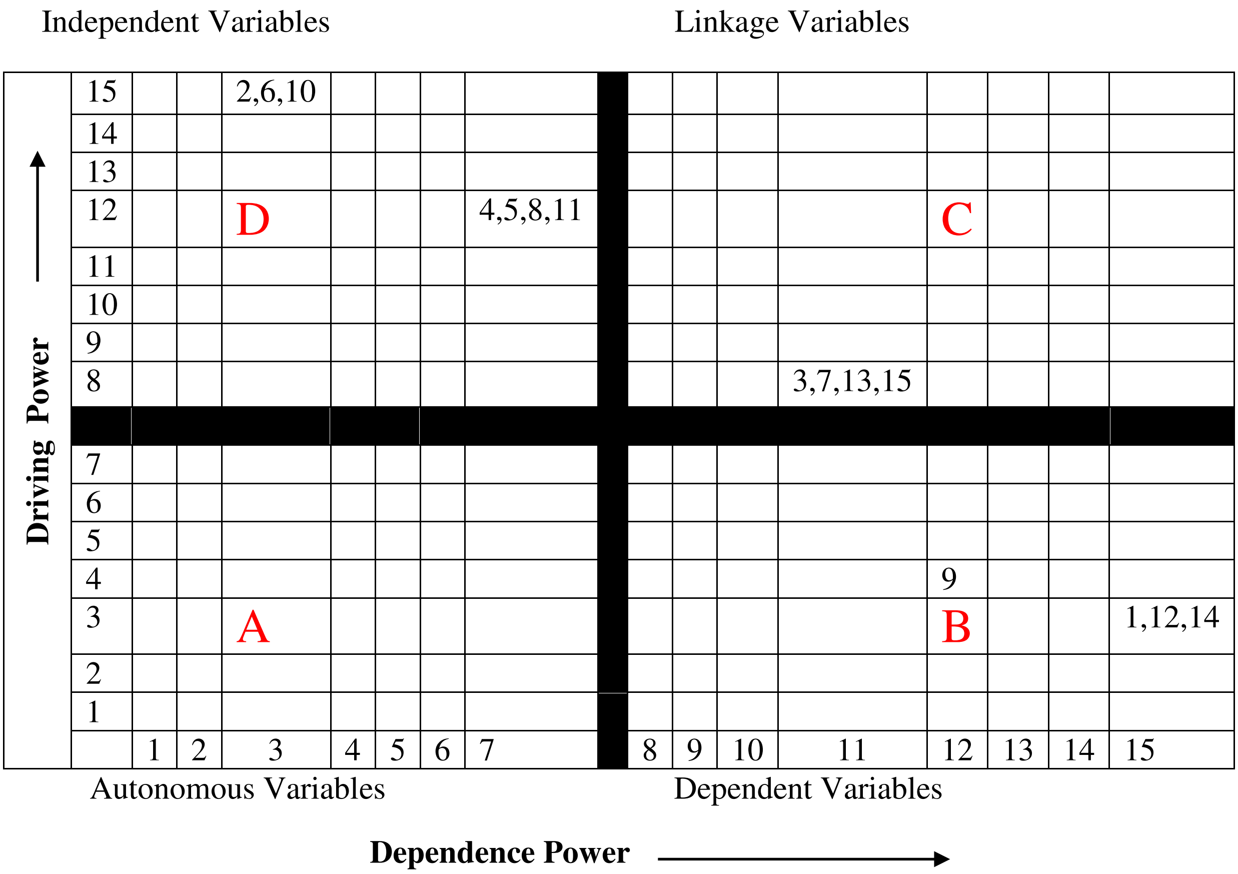


Figure 5. MICMAC analysis of Critical Success Factors of the Smartphone Manufacturing Ecosystem

4. Analysis and Discussions

Figure 4 presents the TISM-based conceptual framework to develop a smartphone manufacturing ecosystem. The direction of relationship has been established on the basis of driving as well as dependence power of factors.

Governmental and legislative support, innovation and technical know-how and global competitiveness emerged as key factors needed in order to develop a smartphone manufacturing ecosystem in India. The Indian government should develop policies that can aid in the promotion of the local manufacturing of smartphones. These policies should include provisions to offer attractive incentives to the domestic manufacturers. India also needs the latest and most innovative technologies that can support the manufacturing of smartphone components in a cost-effective manner. The product should be designed in such a way that local customers' requirements are fulfilled as well as global customers' needs. If government policies are favourable, they will promote innovations and more start-ups will emerge in the market. On the other hand, more innovations through start-ups will generate more revenue inflows for the government and this will further support the government to make user-friendly policies.

Investor-friendly policies formed by the government will enhance FDI. High FDI in the telecom sector will enhance R&D funding by the government and more innovative and high-quality products will be manufactured at lower costs. This, in turn, will develop a good supplier network across the country due to the increase in the demand for such innovative products. With the increase in the manufacturing activities in India, with investor-friendly policies, an upsurge in demand for trained manpower might be observed which could create more technical jobs in the telecom manufacturing sectors. Trained manpower in the industry will enrich the product design as per the latest technology available in the market. Development of physical infrastructure such as power, water, building and roadways will be required to set up manufacturing unit, and infrastructure is one of the highest priorities for a country that is trying to attract FDI. The application store that suits specific Indian customer requirements will increase the purchase intention of the customer for domestic products available in the market. The Indian government can also utilize the application store developed in the market for governance. This means that, not only will the large consumer base be developed, made up of consumers who may prefer locally manufactured products, but the global demand of domestic product may also escalate as well.

The Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) utilizes the multiplication properties of matrices. The main purpose of MICMAC is to classify factors into four clusters, namely, autonomous factors, dependent factors, linkage factors and driving factors. It can be seen from the MICMAC analysis that there are no autonomous factors (Cluster A) which indicates that all factors in the system are interconnected. Factors such as a large consumer base, large handset market potential, growing data usage, growth in export market and a large handset market potential occupy the second cluster (referred to as Cluster B) and named as dependent factors. These factors primarily come at the top of the TISM framework and do not affect other factors above their own level and are highly influenced by other factors such as R&D support, FDI investments, skilled labour available in the market and global demand in the system. Cluster C refers to the linkage factors and act as the connecting link between the dependent factors and the driving factors of the system. Trained manpower, physical infrastructure, application stores that are specific to the Indian market and customer willingness to pay are some of the factors in this cluster and are dependent on factors in Cluster D, such as government and legislative support, innovation and technical know-how global competitiveness, FDI, R&D funding, product design and supplier network. They also drive other factors falling in the Cluster B of MICMAC such as large consumer base, growing data usage, growth in export market and large handset market potential.

5. Managerial Implications of Research

CSFs present in Cluster D are more strategic in nature and need to be securely in place for other factors to perform and top management/administration should pay maximum attention to these. Without these factors working well, no amount of effort would be sufficient to achieve results, which are mainly reflected in the CSFs under Cluster B. In fact, a lot of effort has been put into these CSFs, which have higher dependence power and lesser driving power but the results, as reflected in the current business environment, are either elusive or unsustainable. The model suggests that if the CSFs in Cluster D are well managed on a long-term basis and the CSFs in Cluster C are constantly maintained and updated, the outcome variables under Cluster B will always be reflected by excellent results. Therefore, to achieve an effective smartphone manufacturing ecosystem, which is reflected through a large consumer-base and growth in market (under Cluster B), the right approach would be to first focus on strategic CSFs under Cluster D, including governmental and legislative support, innovation and technical know-how and global competitiveness, and these should be considered from a long-term perspective. There is a great need to facilitate these through a strong leadership and industry support and investment in innovation and R&D. The linkage CSFs, falling under Cluster C, require regular attention, monitoring and fine-tuning in a dynamic business environment. Therefore, skill development and physical infrastructure development both requires regular monitoring and maintenance at the policy and implementation stages.

6. Conclusion

This paper has attempted to provide insights for both academics and practitioners working in the area of smartphone manufacturing systems. Many critical success factors (CSFs) were initially identified for this system and were subsequently subjected to affirmation by evaluating their relevance in the current scenario using expert opinions. The Total Interpretive Structural Modeling (TISM) technique has been used to understand the inter-relationships among these CSFs in the Indian context. The framework developed with the help of the TISM technique can be considered as a conceptual framework for developing an effective smartphone manufacturing ecosystem in India. The framework demonstrates key factors in achieving the smartphone manufacturing ecosystem within the country. Many insights related to the deployment of these CSFs were derived. However, these factors are based on the subjective assessment of the experts in the telecom sector in the country. Furthermore, the framework developed is based on the opinion of a few experts and requires rigorous validation for wider acceptance. Besides these limitations, the current framework marks a foundational effort towards the development of the smartphone manufacturing ecosystem in India. Decision-makers may use the results derived from the framework to promote the ecosystem for smartphone manufacturing in India.

7. Scope for Future Research

This study provides an opportunity to carry out further research in the manufacturing ecosystem in India. The 15 critical factors that ensure the success of building a smartphone manufacturing ecosystem in the country serve as a foundation for discovering the sub-factors behind them. These can further be explored, assessed and validated rigorously. In addition, the framework can be further extended to a more functional form, which may help organizations to calculate the level of operational excellence achieved by considering the drivers of the framework.

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Appendix 1

Interpretive Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	-	-	-	-	-	-	-	-	-	-	Consumer base enhances manufacturing potential
2	Public perception on the basis of govt. support	-	Skill development	Investor friendly policy	Risk mitigation and global competitiveness	Promotes start-ups	High cost infrastructure through govt. funding	Govt. infrastructure helps product development	Consumer confidence	Govt. support for resources and policies	Supplier confidence	Investment-friendly environment
3	Consumer confidence builds up	-	-	-	-	-	Skilled resource available	-	Skilled labour available	-	-	Skilled labour available
4	FDI attracted by market potential	-	More manufacturing activities	-	FDI towards R&D in tech. product	-	Infrastructure investment		Market Potential	-	Component supply	Investment for manufacturing
5	Consumer confidence on indigenous technology	-	More people required for R&D	Low cost R&D	-	-	Low cost infrastructure development	1nhouse technology development	Strong IPR base	-	Low cost R&D	Indigenous technology
6	Consumer confidence builds up	More revenue inflow	More people gets involved	Investment in start-ups	Innovation builds up R&D base	-	Tech. for low cost infrastructure development	Innovative product developments	Innovation for local needs	Capacity to design innovative product	Market pull for more supplier	Translate customer need to product development
7	Consumer confidence builds up	-	More jobs available	-	-	-	-	-	Attracts investments	-	-	Accessibility to raw materials
8	Consumer confidence builds up	-	More talent available	IPR acquisitions	1nhouse technology development	-	Low cost infra. Solution	-	Tech. availability	-	More components required	Tech. availability
9	More consumers more market potential	-	-	-	-	-	-	-	-	-	-	More demand for innovative product
10	Consumers prefer global quality	Potential revenue source for government	Skilled manpower for global quality	Quality in low cost	High quality R&D	More requirements of components	Quality demand for better infra	More innovation	Large Market base	-	More component are required	Large market base
11	Consumer confidence builds up	-	Job availability	Improved supply chain	Low cost R&D	-	Wider the supplier n/w more infra. required	Easy accessibility for experimentation	More availability of component	-	-	Good coordination with OEMs

12	Local products preferred	-	-	-	-	-	-	-	-	-	-	-
13	Meets consumer utilities	-	Job potential	-	-	-	More start-ups demand more infra.	-	More utilities on handset	-	-	More apps makes handsets more user friendly
14	Global consumer market	-	-	-	-	-	-	-	-	-	-	Competitive product development
15	Economically visible	-	Increase sale need more trained manpower	-	-	-	More sale of the product	-	More demand	-	-	Global demand