Modeling Technology Diffusion to Integrate Medium Scale Clustered Manufacturing Industries Development

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Authors' Declaration

I, Mehret Getachew, declare that this thesis entitled "Modeling Technology Diffusion to Integrate Medium Scale Clustered Manufacturing Industries Development" is my original research work and no material has been submitted previously for the award of any other academic degree.

The research work was done under the guidance of Dr. Ameha Mulugeta and Fitsum Getachew (PhD Candidate), at Addis Ababa university, Addis Ababa Institute of Technology School of Mechanical and Industrial Engineering.

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Abstract

Development of manufacturing industries is an ever-growing concern for Ethiopian government. Medium scale clustered manufacturing industries are given more focus with an intension of substituting the domestic market with a quality local products and for the export market. Technological advancement of the manufacturing process is a critical landmark for these industries to be competitive. Adoption and diffusion of technologies inside the cluster is quite limited. Lack of technical knowhow and appropriate technology is the major constraint for industries development. This is due to low access of cooperation with supporting organizations (research institutions, industry extension, universities and financial institutions), lack of internal integration (inside the cluster) and the policy to get a loan. On literatures regarding technology diffusion models less emphasis is given for the concept of cooperation and integration. Therefore, the main objective of this research is to develop technology diffusion model that considers driving factors for accelerated adoption and diffusion of technology in industrial cluster in order to enhance integrated development.

This research used both qualitative and quantitative methods and a combination of both primary and secondary sources of data. The research conducts an extensive literature review of technology diffusion models, industrial clusters and integration of industrial clusters. Under eight manufacturing subsectors, Leather and leather goods subsector is selected using weighting factor analysis by considering different selection criterions. Ethio-international foot wear clusters cooperative society Ltd is taken as a case. Primary and secondary data were collected from enterprises, research institutions, learning institutions, financial institutions and regulatory offices.

From the primary and secondary data sources, internal and external factors affecting technology adoption and diffusion in industrial clusters are identified and prioritized using AHP. BASS diffusion model is implemented to understand the existing rate of technology diffusion in the cluster taking sample technology, Heavy duty stitching machine. Based on the prioritized factors, agent based model of technology diffusion is developed which includes Fuzziness on the adoption decision, a model which is the first of its kind for industrial clusters in Ethiopia. In order to validate the model, the existing diffusion pattern of the machine is simulated and an experiment of three scenarios are made on NETLOGO. As compared to the result obtained from Bass model, the simulation result shows reduced rate, from 6 years to 4 years with 100% adoption probability and 3 years with 80% adoption probability. It can, thus, be argued that external cooperation and internal integration are important technological advancement opportunities for industries.

Key words: Technology Diffusion, Industrial Cluster, Integration, Agent Based Model

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Abbreviations and Acronyms

AAIDO	-	Addis Ababa Industry Development Office
AAIT-UIL	-	Addis Ababa Institute of Technology University Industry Linkage
ABM	-	Agent Based Modeling
AHP	-	Analytical Hierarchy Process
CSA	-	Central Statistical Agency
DBE	-	Development Bank of Ethiopia
EIFCCOS	-	Ethio-International Foot Wear Clusters Cooperative Society Ltd
FeSMEsDA	-	Federal Small and Medium Enterprises Development Agency
HDSM	-	Heavy Duty Stitching Machine
IC	-	Industrial Cluster
IE	-	Industry Extension
LIDI	-	Leather Industry Development Institute
MOI	-	Ministry of Industry
SMEs	-	Small and Medium Enterprises
UNIDO	-	United Nation Industrial Development Organization

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Chapter one

Background and Justification

1.1. Introduction

The strong interest for developing countries to expand their access to international technologies is understandable in light of rapid technological changes in the global economy. The ability to learn from foreign technology, adapt to, and import them into domestic competition is critical for achieving sustained economic transformation and productivity growth (Maskkus,2004). Developed and developing nations are constantly striving to keep pace with ever increasing advances in technological progress (Comin and Mestieri, 2013*)*. Demanding the undivided attention of both, technology transfer and diffusion is becoming a primary component of international assistance. Technology can be transferred and diffused in a variety of ways and for several reasons. The three most prominent situations in which technology transfer and diffusion occurs are within the realms of science and technology themselves to further the cause of those disciplines within a societal level from one geographical location to another for economic gain and from one societal level, both nationally and internationally, ostensibly for development (Imen and Fethi, 2015).

Technology is the way the human and physical resources can be mixed to produce the output. This technology can be tangible such as new equipment, and it can be intangible such as a new prototype design that can be followed to produce a certain outcome. Technology when adopted, and diffused enhances the productivity of labor, and hence the economic output. Technology is a general knowledge or information that permits some tasks to be accomplished. Transferring these knowledge or information from the source to the recipient and when absorbed is technology diffusion.

Technological diffusion is a key element in upgrading developing countries. Technological change may be seen as a specific feature of the broad concept of "structural change", seen as different arrangements of productive activity. Human capital is a pre-requisite in order for new technology to be used. Lack of technical skill or skilled labor in the developing country to adopt and master new technologies causes the technology to be diffused slowly. Technology transfer differs depend on the Type of industry to be studied, Human capital, Importance of trade and foreign direct investment. It would be efficient for developing countries to acquire foreign technology created in the developed countries (Murzidah and Douglas, 2011).

Cluster development programs have become increasingly widespread tools in fostering innovation and growth of a competitive private sector in developing countries, including Ethiopia (Merima et.al, 2016). The role of small and medium Enterprises (SMEs) in providing employment opportunities and boosting entrepreneurship and innovation has emerged as an important concern for policymakers and other stakeholders. Manufacturing SMEs serve as important sources for sustainable job opportunities not only for developing countries but also for developed countries (Wolday and Tassew, 2015).

It has a vital role concerning on these enterprises technology adoption capacity. Ethiopia has placed great emphasis on the acquisition of new technology to enhance capabilities of SMEs in setting forth a new age of manufacturing products for local and export markets. To achieve this goal SMEs are given recognition in the country's current industry development plan and are considered as a vehicle for employment generation particularly in urban centers and leading to economic development (FDRE, 2011). Technology adoption and diffusion assist integrated development of industries in the cluster.

In this research greater emphasis is given on cooperation of industrial clusters with supporting organizations to enable industries to adopt new technologies and accelerate the diffusion rate in the cluster for integrated development of industries.

1.1. Problem Statement

In the development and sustenance of a community, state, or nation, the advancement of technology is vital for survival. Here, the needs for technology adoption and diffusion arises and becomes a critical landmark. Ethiopian government is giving more attention on the development of industrial clusters around the capital city and throughout the country in order to open a wide opportunity for micro, small and medium enterprises. Medium-scale manufacturing industries are playing an ever-increasing role in the manufacturing industrial structure of the country. SMEs often operate in the informal part of the economy and they do that side by side with a small number of large firms that are mostly foreign owned, capital intensive and have better access to geographically wider markets. However, the nature of the SMEs in Ethiopia is an indication of the “missing middle” where we do not often see SMEs gradually growing into large size firms and eventually strong competitive ones. Also, from the report of UNIDO (2016) SMEs are characterized by

- Low access to appropriate technology
- Limited ability to acquire skills and managerial expertise
- Low productivity and constitute an insignificant share of the commercial output
- Poor access to quality inputs and
- Business infrastructures are among the constraints.

According to UNIDO (2016) report the major challenge for this clusters to be competent is lack of technical knowhow and appropriate technology which accounts 36%. During the preliminary interview held with Mr. Getahun, the federal small and medium enterprises development agency technology transfers and development directorate director; he depicts the major problem for the enterprises not to be technologically competent are identified here as the major problems;

- Low access of cooperation with supporting organizations (research institutions, industry extension, universities and financial institutions)
- Lack of internal integration among enterprises (inside the cluster) that would help to share different technologies
- The policy putted as a prerequisite to get a loan to adopt new machine and technology.

This makes the enterprises to suffer from lack of technological capability which results from very slow adoption and diffusion of technology in the cluster. There is a lot to be done regarding accelerating technology diffusion to these industrial clusters to upgrade their business to large scaled industry.

According to the cluster development directive, Government created clusters are considered as incubation centers where SMEs are provided with various supports, in which they eventually can grow into large and competitive firms. However, they are not working together with the supporting organizations and can’t be technologically competitive. In this paper influencing internal and external factors for faster diffusion of technology are investigated with an intention of developing technology diffusion model which will focus on cooperation of SMEs with the support value system and integration with each other.

1.2. Research Questions

The research aims to answer the following three basic questions related to technology adoption and diffusion in industrial clusters.

- How is the existing rate of diffusion of technology in industrial clusters of Addis Ababa?
- What are the internal and external factors that affect adoption and diffusion of technology for SMEs in industrial cluster of Addis Ababa?
- What type of technology diffusion model should be developed in order to accelerate diffusion of technology for integrated development of SMEs?

1.3. Objectives of the Research

General objective

The general objective of this research is to develop technology diffusion model which considers driving factors for accelerated adoption and diffusion of technology in industrial cluster in order to enhance integrated development of SMEs.

Specific objectives

To attain the general objective set forth, the following specific objectives have been identified. These are;

- To identify the internal and external factors that affect adoption and diffusion of technology in industrial clusters
- To assess the level of integration among SMEs in industrial clusters and cooperation with supporting institutions
- To analyze the rate of diffusion of technology based on the existing level of integration and cooperation
- To develop and simulate a technology diffusion model based on an influencing internal and external factors.
- To propose a recommendation based on the simulation result

1.4. Significance of the Research

This research contributes for better understanding of factors that influence technology adoption and diffusion in industrial clusters. Detailed understanding and analysis of the factors will be taken as a showcase for SMEs technology adoption. The model illustrates the benefit gained from the interaction of various stakeholders with the enterprises with the concept of agent-based model. Simulation result of the model assist various stakeholders to get an insight about the benefit gained with an integrated effort. Significances of the research are thus to:

- Enable deep understanding and knowledge of cooperation of stakeholders with the enterprises for technology adoption and diffusion
- The model gives an insight for the enterprises that the benefit gained from integration with each other for accelerated technology diffusion.
- Propose recommendations for the concerned stockholders based on the extensive analysis and the simulation result that creates confidence for implementation.
- Policy recommendations helps policy makers of Ethiopian manufacturing industries on strategies related to enhancing technology adoption capacity.

1.5. Limitations of the research

In this study questionnaires and interviews are used as data collection tools with the support of secondary data. This type of personal judgement data may have a potential to be the source of bias. Additionally, since the concept of rating the diffusion of technology in industrial cluster is new and not researched before in Ethiopia, it was difficult to get the diffusion history of analogy technology. However, the researcher takes similar diffusion history from other developing country. This may limit the reliability of the research result. However, the limitations do not affect the quality of the research addressed within its scope, the researcher verify and validate the result through scientific analysis.

1.6. Scope of the Research

The research topic will only cover the technology adoption and diffusion of medium scale clustered manufacturing industries under Addis Ababa industry development office. This study will only focus on the diffusion of technology inside the cluster and adoption of technology from the support institutions. To narrow down the case Leather and leather product manufacturing subsector is selected from the eight different manufacturing sub sectors. Moreover, Ethio-international cooperative foot wear clusters cooperative society Ltd. (EIFCCOS) is selected for the data collection and analysis.

Chapter Two

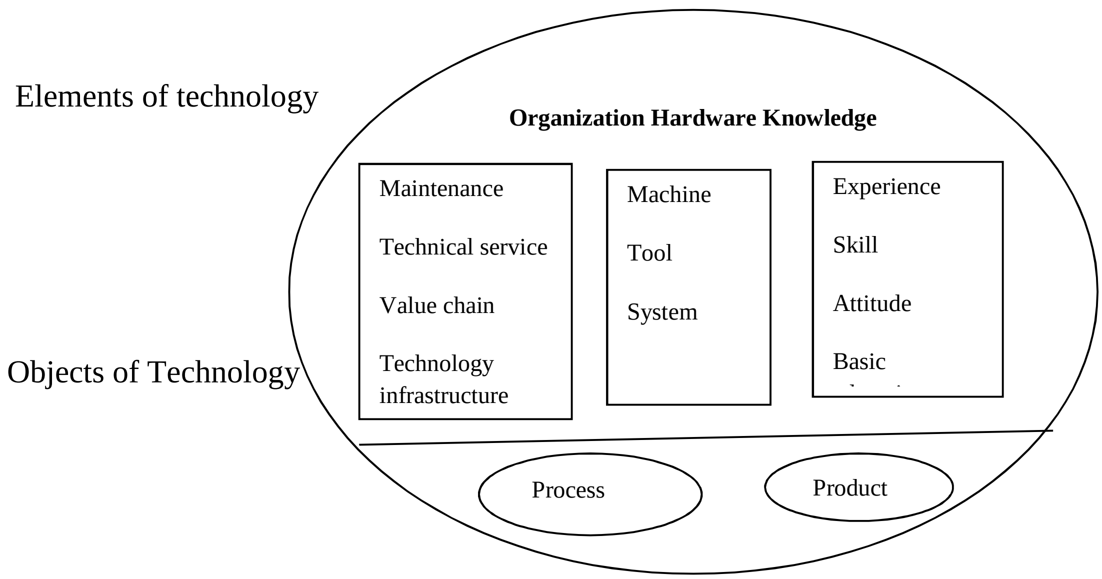
Literature Review

In this section, the relevant literatures were explored in order to provide background information about the research. The literature review covered three main topics. The first deals with models of technology diffusion, the second with Industrial Cluster (IC) and the third with the integration of industrial clusters.

2.1 Introduction

It is evident that an important consideration is given to technology diffusion since it is an important route to increased competitiveness, especially on the manufacturing sector (Brychan, 2000). Diego Comin and Mart Mestieri (2013) define technology as "a manner of accomplishing a task especially using technical processes, methods, or knowledge". The broad classification of objects of technology can be as process and product technology (Stamer, 2007). Other researchers divide technology as "hard and soft technology hard technologies such as computer-controlled machine tools and soft technologies such as, improved manufacturing, quality, or training methods" (Shapira and Rosenfeld, 1996).

"Technology diffusion is the adoption of a technology by a population over time" (Kemp & Volpi, 2008, p. 4). The term is used to describe the aggregate adoption of a new or existing technology around the community or deep inside knowhow or learning about the technology. Technology diffusion differs according to the type of technology to be diffused as "disembodied" and "embodied" diffusion. Disembodied type of technology is like that of technical knowhow and knowledge which is the soft part and embodied technology diffusion is the existence of new equipment's and machineries that will approves that there is a new technology (Brychan, 2000). In addition, technology can diffuse through different ways and with significant variations, depending on the type of technology, time, space, and between different industries and enterprise types. Moreover, the effective use of diffused technologies by firms frequently requires organizational restructure, workforce change, and different follow-on technical changes (Shapira and Rosenfeld, 1996)



Source: Jörg Meyer-Stamer, 2007

Figure 2. 1. A broad definition of technology

R. Kemp and M. Volpi (2008) on their study about clean production, they describe technology diffusion by pointing out ten stylized facts which are "technology adoption is not instantaneous; There are usually different innovation from which a company can choose. The diffusion of one innovation affects the diffusion of the other innovation, Technology diffusion involves information transfer and has elements of innovation, technology diffusion is not simply a matter of information transfer, the more economically attractive a technology is, the more quickly it will be adopted and the greater the number of companies that will adopt it, an economically attractive technology does not automatically get adopted the moment it becomes economical to use it, the technology for diffusion is not constant but steadily improves this affects technology diffusion, expensive and complex technologies tend to diffuse more slowly, the population of potential adopters changes over time, technological diffusion tends to follow an S shape curve"(Kemp and Volpi, 2008, p. 7).

2.1.1 Technology Transfer and Diffusion in Different Countries

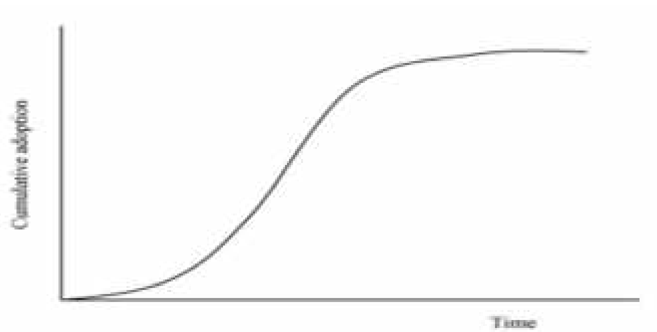
Technology transfer and technology diffusion are often used as substitutes for one another as both the terms are used to express dissemination of innovation from one party to the other (Gustav, 2009) but it is suggested that equating them may be partly misleading. Their difference can be seen in two perspectives the first is technology diffusion is not about the adoption of the technology for a single consumer or firm as transfer but rather the adoption decision of potential adopters (Nichols, n.d) the other perspective is transfer of knowledge and legal rights to produce a new product is constrained by the owner's concern for a return on innovation on the other hand technology diffusion is restricted by willingness and ability of the users to adopt it not the owner (Stamer, 2007). Technology can be transferred without being diffused but not diffused without being transferred.

The process of technological diffusion here is determined by the channels of technology transfer and the technological capabilities in the follower country or firm. The level of firm knowledge accumulated within the receiving country makes up these capabilities (Sillah, 2014). Murzidah and Douglas (2011) on their study about the importance of technology diffusion in Malaysian Manufacturing SMEs they identified the problem that Malaysian manufacturing SMEs is less than effective, or that less than competent and they showed the reasons for adopting or not adopting new technology into their business operations (Murzidah and Douglas, 2011). Sillah (2014) on his study of Saudi Arabia’s manufacturing industry technology transfer technology is an endogenous variable in the presence of human capital; and that the higher levels of educational attainments are found to significantly improve factor productivity. The capital goods import and the domestic R&D expenditure are found to be negatively associated with the technology diffusion as he concludes in his study of human capital, foreign direct investment stock, trade and the technology diffusion in Saudi Arabia.

Different countries had different experience with regards to technology transfer since there is difference in culture, attitude, market competitiveness and other. Imen and Fethi (2015) on their research about the Tunisian manufacturing sector they draw a conclusion that “openness to foreign companies and the Trade in Information and Communication Technologies (ICT) had a significant role in the diffusion of technology but the presence of foreign firms has not been a vehicle for technology diffusion for the Tunisian manufacturing sector” (Imen and Fethi, 2015, p. 12). Since the countries have different scenario researches are being held in different manufacturing or service sectors. Most importantly there should be an interaction of firms with each other nationally or locally rather than competing immediately with international firms since their interaction with each other will strengthen the firm and enable it to be competent internationally (Padmore and Gibson,1998). However, the higher level of economic integration may affect the growth of the country and also environmental impacts as Michael hubler (2010) studies the china energy specific technology diffusion on his paper of Technology diffusion under concentration and convergence he indicates that china's economic integration is causing environmental impact so that he introduces a mechanism of international technology diffusion via FDI and trade in to CGE modeling for climate policy analysis. So that thinking of technology diffusion internationally there should be an emphasis given to some soft issues like climatic policy (Hubler, 2010).

2.2 Models of Technology Diffusion

The concept of modeling technology diffusion process was first come from the theory of growth of a colony of biological cell in a medium; since a growth of a cell would be limited due to different constraints like limited nutrients or space gradually it would slow down and saturate resulting in an S curve pattern (Rao and Kishore, 2010). The same is true for the model of diffusion of technology; it is dependent on the cumulative adopters of that technology and the time taken to adopt that technology (Rao and Kishore, 2010). As indicated for the growth of the cell, the growth of new technology or innovation follows the same pattern initially it will grow slowly then at the medium level becomes rapid then again it will have constant rate as indicated on an S curve. This adoption curve is derived from a symmetric bell-shaped curve that describes the distribution of adopters over time. Ryan and Gross (1996) on their research of hybrid corn the central question was what factors influenced its adoption and the result was communication between previous and potential adopters is very important and from the result they discovered the S shaped rate of adoption. Even today most studies of technology diffusion found the same pattern as that of S curve.



Source: K.U. Rao, V.V.N. Kishore/Renewable and Sustainable Energy Reviews 14 (2010) 1070–1078

Figure 2. 2. Diffusion curve or a typical S curve – cumulative adoption vs. time

During developing technology diffusion model there shouldn't be only one thing to consider which is trying to transfer one firm's strong side to other by ignoring the issue that how to minimize the unproductive activities. Thomas Brychan (2000) on his paper of model of the diffusion of technologies in to small and medium enterprises he considers two things which are "best practice" and "low activity can be improved". He develops a technology diffusion model for SMEs by considering different factors of internal and external networks or channels of technology transfer and the way that the technology transferred or mechanisms (Brychan, 2000).

The smaller industries or firms adopt new knowledge or technologies in slower rate as compared to those large firms, and those more profitable technologies are adopted faster. This indicates that most of the time small firms are not concerned on upgrading their working condition rather focused on things that will accelerate their profit (Diamond, 2003).

Technology diffusion for industries found in developing countries specifically for those small and medium enterprises plays an important role. Since, they cover most of the manufacturing capacity of the country and their products will be distributed throughout the local market and even for the export market their competitiveness will be increased if only there is an inter firm technology diffusion (Brychan, 2000). He defines Technology diffusion as "the spread of a new technique from one SME to another ('inter firm diffusion')". Others distinguishes the term inter firm diffusion from intra firm as the former is the proportion of enterprises or firms using the new technology within the sector while the latter is all about internal diffusion of the technology or the level of usage of the technology inside the company (Sarkar, 1998).

Innovation diffusion model suggests that a technology or innovation is accepted or rejected by the community over time (Lee, 2004) on his paper of the application of Roger's innovation diffusion model. This indicates that if the technology is accepted or rejected through that group of people by taking a long time, it also takes probably more time to be diffused because it can only be known whether the technology is recognized as useful or not once it is diffused. On the other hand, the diffusion of technology may vary according to the organization or the firm. Some firms adopt the new or existing technology in a very short period of time and others will adopt it even after decay (Silverberg, et.al, 1988).

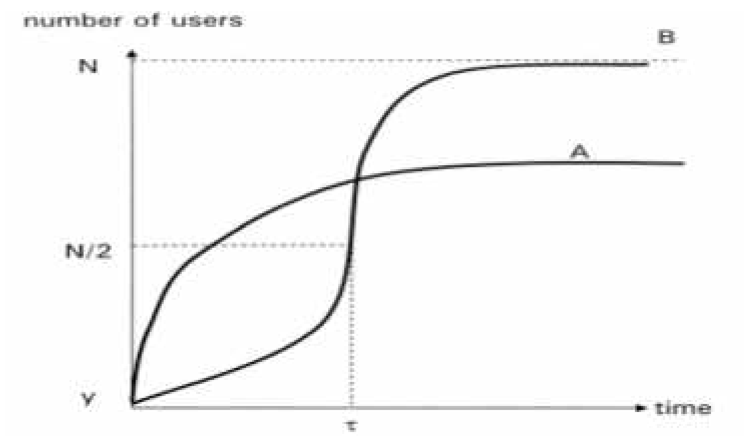
There is a question arises in every one mined that is why technology diffuses slowly there might be a lot of reasons which will confront this idea. Sometimes it seems to take an amazingly long period of time for new technologies to be adopted by those who seem most likely to benefit from their use or from that technology (Geroski, 2000) these leads different researchers to deal with developing technology diffusion models. Among the different models those which are reviewed are discussed below.

2.2.1 Epidemic Model

In practice it is obvious to see differences among firms regarding adopting new technology in which some of them may use the technology at its early stage and others will be lagged. (Arthur et.al, 1987) if that new technology is really important to use other than the existing or the old one it should be adopted by all firms which will be benefited from that technology. But what is obvious is that firms adopt new technology slowly (Geroski, 2000). The concept behind this model is that information is a key for the faster or slower diffusion of technology or for the rate of technology diffusion. Looking critically to an S curve of technology diffusion, the rapid growth time of technology diffusion is sandwiched between the very slow time at the beginning and at the end so one should think that what would be reason for that specific period that technology adopted rapidly. The most popular explanation of these phenomenon or S curve is epidemic model or “information diffusion”. So that in this model the most important thing for firms to adopt new technology is information. And what makes the different rate of technology diffusion for firms is also the spread of information.

Epidemic model considers information to be the key to diffusion. As more people adopt the technology, information of it spreads quickly leading to a period of rapid adoption. The epidemic model models technology as “contagious disease”. Adoption occurs as potential adopters learn about the new technology. Adoption is slow at first as few people or firms know about the technology the more people “infected” that is those that have adopted the more likely others will also be infected thus as information spread a period of rapid adoption follows (Arthur, 1989). Beside an epidemic model in which the key diffusion factor is information, there are other principles putted on the model keeping awareness and information spreading. “The essential prediction of a theory of diffusion is that potential adopters of a new technology should have different (preferred) adoption dates, or, synonymously, that at any given date only some of the potential adopters will wish to be (or are sufficiently informed to be) actual users." (Karshenas and Stonman, 1993, p. 9) this results from different mechanisms among that rank effect is the one. The idea behind this is the different inherent characteristics of the potential adopters of a technology results difference on the outcome of adopting the technology.

The other is Stock effects these effects result from the assumption that the benefit to the marginal adopter from acquisition decreases as the number of previous adopter's increases (Karshenas and Stonman, 1993). Epidemic model mainly takes in to account those sources of technology as hardware and software "without good software knowledge, many potential users will not adopt the new technology, however aware they are of its existence" and by taking the length of time of the technology *t* and the number of adopters as N and those who use that technology at that time *t* as *y(t)* and the number of those who don't use that technology at time *t* as *N-y(t)* to calculate the effect and the reason for that difference by considering information cascade as a key factor (Geroski, 2000).



Source: P.A. Geroski Research Policy 29 (2000) 603–625

Figure 2. 3. Plots of the modified exponential A and logistic B diffusion functions

The major shortcoming of this model or the gap seen is on the assumption taken to develop a model that is once potential adopters learn of a technology, they will use it. It will lead a researcher further to look at the model because there are some uncertain conditions that everyone who know the technology may not apply it by this reason it is difficult to say that the technology is adopted since it is not applicable and seen any result or change for the firm. The other assumption is that the quality of the technology is the same over time these is also the other problem with the model in which the technology will be outdated after some period of time especially in today's world of high competition it is difficult to work with similar machines and equipment and even with the same technical knowhow for a long period of time so that it's a must to make some modification on the model. Because of the above pointes raised other models which will overcome these assumptions are developed.

2.2.2 Equilibrium Models

Recent works on the diffusion of technology are majorly focused on explaining the prevalence of the S shaped diffusion curve in which both the disequilibrium and equilibrium models of technology diffusion are based on the early s curved diffusion pattern. Equilibrium model assumes that there is perfect information about the technology which explains the irrelevance of epidemic model (Sarkar, 1998). As mentioned above on the epidemic disequilibrium model majorly focused on the spread of information but on equilibrium model initially there is information on the technology rather there are differences among users that explain gradual diffusion (Sarkar, 1998) here what makes the diffusion of technology slow is the difference among users even if having an information about it. Generally, the equilibrium model says that Firms must pay a cost *ct* to adopt a technology at any time *t* considering the price is not constant in which it may vary over time and firms should understand that the benefit of the adoption of a technology at the given time is much more important than the cost they pay for the adoption of the technology (Chatterjee et.al, 1998). The implication behind this model is that of gradual diffusion is rational it is the result of profit maximizing behavior rather than a market failure. Among the different types of equilibrium models some of them are discussed below.

2.2.2.1 Rank or Probit Model

Probit model is also known as rank effects model because of the ranking of adopters or the population through different dimensions (Karashenas and Stoneman, 1993). In this model the central idea is potential users of the technology differ in some important characteristics which in turn causes some to adopt earlier than others in both cases of inter and intra firm diffusion or difference on the choice of adoption of individuals or firm. As Sarkar (1998) explains on his review of neoclassic models he explains the reason for the difference among the population to adopt the technology. That is at any instant the critical level to elicit adoption is not a unique value appropriate to all members of a population. Instead, the critical value is distributed heterogeneously across the population according to some density function and adopters can be ranked in terms of the benefit to be obtained from the new technology. Some important examples of rank effect are like “firm size, R&D expenditure, market share, market structure, input price, characteristics of the technology and government regulation” (Baptista, 2000, p. 6). They found that government utilities are slower to adopt new technologies than privately owned ones it seems similar to local country case in which private firms are more competitive and close to using new technologies as compared to government organizations. Similarly, firm size plays an important role for the rate of diffusion often small firms are less capable to adopt technology within a minimum time and large firms are able to adopt and even to be innovators since they are strong because of the staffs they have (Rogers, 1995).

The trick behind Probit model is to clearly identify the dimensions or characteristics which generates differences among firms or individuals and the associated costs of adoption like supplier related costs, learning and search costs, switching costs because of less absorptive capacity some firms stay on one technology for a long period of time at that time there is a cost they pay indirectly because of losing the new technology and opportunity costs (Geroski, 2000).Geroski shows the Davies model as that the precise shape of the diffusion curve depends on how xi (the characteristics) is distributed across the population, and on how x^* (the threshold) changes over time.

2.2.2.2 Stock Model or Game Theoretic Approach

Among the diffusion models which have nothing to do with the information diffusion and can generate S curve stock adjustment model is the one. As the number of users of the new technology increases the gross benefit from the adoption declines (Baptista, 2000) it can be due to the effect of technology adoption on prices or due to prices in factor markets (supply effect) it directly related with the outcome of adoption which is price. And as the technology is used as a mass or majorities uses the technology it will not have competitive advantage (Karashenas and Stoneman, 1993). It seems a bit contradicted with the idea of epidemic model here as the number of adopters increases the benefits gained will be decreased in other view it is a good starting point for searching the effects of spreading new technology within a minimum time span.

There was similar reflection among different researchers (Arthur and Lane, 1993, Geroski, 2000 and Sarkar, 1998) argued as the benefit gained from technological diffusion is “density dependent" it is to mean that as the number of firms using that technology increases the benefit gained will decrease. Arthur (1989) analyzes the model taking different scenarios for example if there are multiple equilibria of technologies and interdependencies among adopters on their decision criteria. As Bpista (2000) explains the argument of Reinganun (1981a) even if the benefit from adoption declines because of the increased number of adoption, there will be a point in time when the number of cumulated adopters makes adoption because of the remaining firms not profitable.

As Reinganum (1981a) puts an assumption on her model there are "positive" and "negative" externalities of an increased adoption.

The strategy to be followed is that of the optimality of time to adopt the technology which will lead to be competent. The idea behind the negative externality is adoption cost decreases over time and the profit to be gained from adoption decreases with an increase in the number of users (Reinganum, 1981a) unlike Probit model she assumes "firms should pay equal cost for adoption, information on technology is perfect, firms maximize the present discounted value of profit and firms undertake strategic behavior in an oligopolistic market setting.". On the other hand, the positive externality can be seen as informational externalities during the process of adoption or it can be generated from the benefits gained from a growing network of products and services and the cost saving that follows from standardization and mass production (Sarkar, 1998).

Reinganum's (1981a) work takes in to account that firms should have a strategic interaction and a precondition to adopt a new technology at similar time span and also should incurred similar cost for adoption so that there will be positive and negative externalities for firm's adoption strategy since the firms use and diffuse the technology within similar time. This result will lead to the absence of diffusion curve or S curve because there will not be an issue of early adopters and lagers.

2.2.2.3 Order Model

The firm's position in the adoption order determines its gross return from adoption. Early adopters typically get a higher gross return this suggests the first mover advantage dominates the advantage of waiting for better technologies. However, costs are important to get net return from adoption thus there is a tradeoff between first mover advantages versus higher early costs

(Chatterjee et. al, 1998) and (Sarkar, 1998). As the researchers argued that early adopters will be benefited this happens because of many reasons it could be because of early market penetration with a new product or service. Here the researcher argues that as much as possible firms or individuals who involve in a similar sector should get a new working style or technology at equal time as possible to be benefited from that technology unless if one is early adopter and the other laggard then there will be a gap between firms but as the researchers argued even if early adopters will be benefited, looking cost wise there is an offset between higher early costs and higher early adoption benefit.

Further exploration of this model taken from the population ecology literature S curve can be derived (the effect of natural setting of birth and death rate). There is the process of "Legitimation" and "Competition" (Geroski, 2000).

Similarly, there is a diffusion time of early period and late period during the early period of diffusion the process undertaken is legitimating broadly, "whether it will work, whether it is superior to any other new technologies which might possibly arrive in the near future, whether there is a supply infrastructure available to support adopters, whether buyers will resist products made from the new technology, and so on" in general, standard setting process (David and Olsen, 1992). After some time, the process of Legitimation ends and as it continued to be adopted competition for the products of that technology will be started resulting lowering of return of early adopters and also non-users will fear to adopt the technology and finally the diffusion rate slows and ends. As P.A. Geroski (2000) puts in short initially the competition is between the old technology and new technology then, it will be between different firms who uses the new technology.

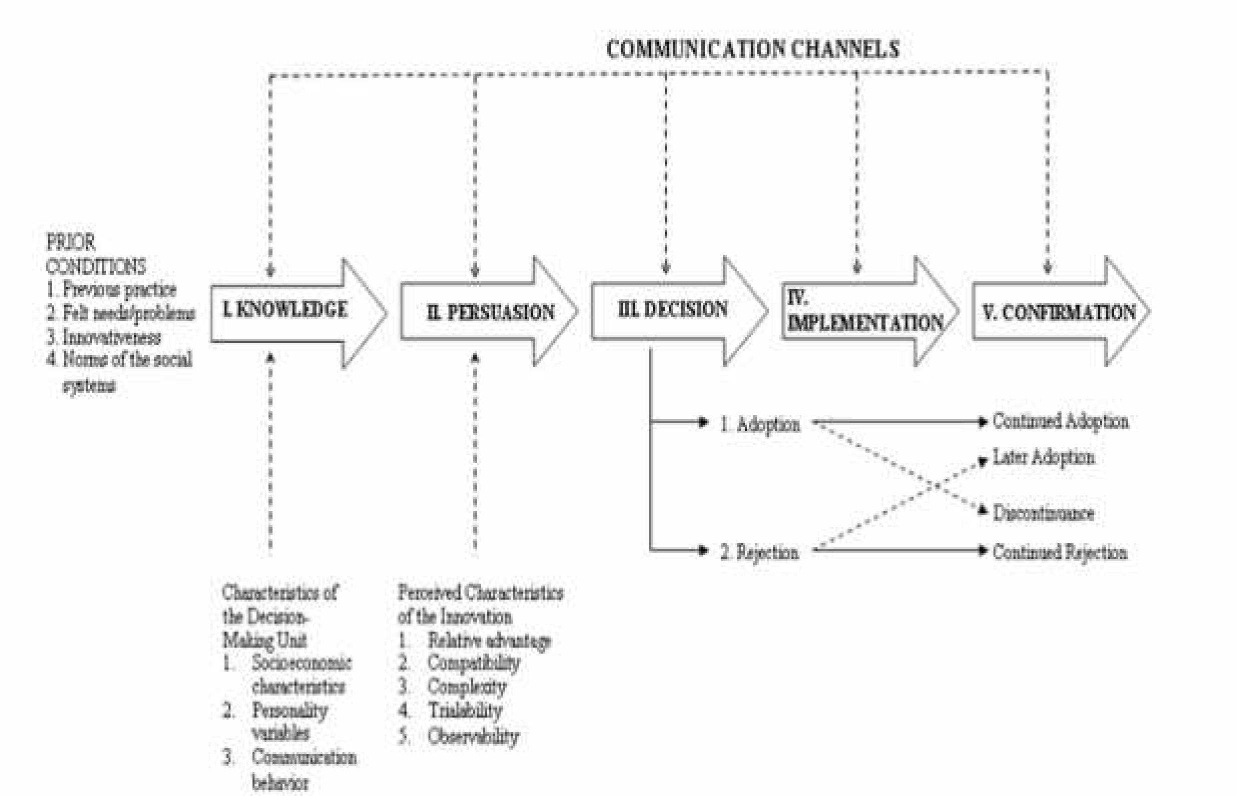
Others defend that why always thinking that S curve is a correct assumption for technology diffusion since S curve models an innovation or technology as it will fail after some period (Rao and Kishore, 2010) it seems reasonable to think that after some diffusion period technology will fail or stay for decay as it is and being used vastly.

In the other perspective technology diffusion can be held through "information cascade" (Geroski, 2010). He starts from assuming that there is a variety of new technology in the market say "A" and "B" then early adopters of the technology use one of it as a trial and adopt "A" through time the technology is legitimated and many firms start to use technology "A". As the researcher concludes from the model, from the alternative technologies exist firms try each to select the profitable one but during that process the first technology selected will stay a long time since the information cascaded from early users to the wider market (firms).

2.2.3 Rogers's Model

Everett M. Rogers analyze the diffusion of innovation on several agricultural innovations in a rural agricultural community of Iowa and he concludes that the diffusion of innovation follows the structure of the process of social change (Rogers, 2004). Different researchers apply Rogers model, Ting-Ting Lee (2004) evaluate nurse's adoption behavior by applying Rogers model on his study of nurse's adoption of technology and the result he found indicates that Rogers' model can exactly describe nurse's adopting behavior of workplace innovations. Singhal A. & Dearing J.W. (2006) wrote a research paper of the communication of innovation in which they dedicate it for their senior Everett M. Rogers and they elaborate the dominant paradigm for the diffusion of innovation and also the distinctive aspects of diffusion.

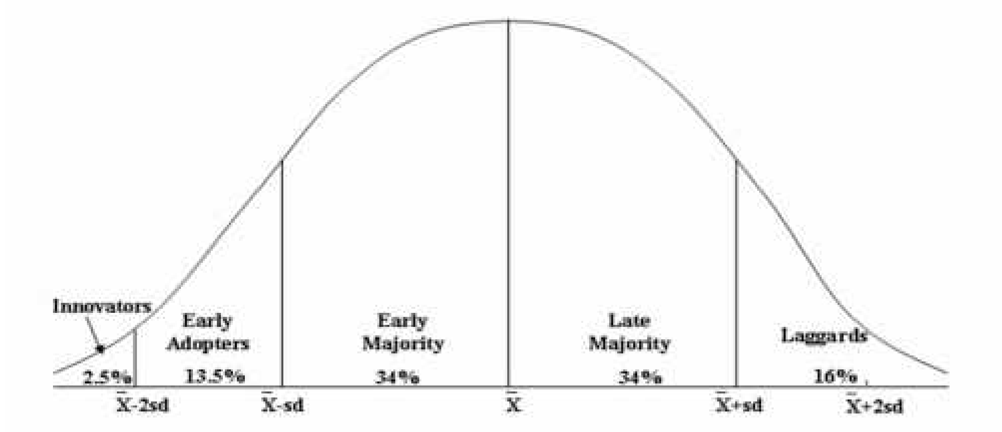
He puts four interacting elements for diffusion of technology which are innovation, communication, time and social system (Rogers, 2003). Rogers proposed a set of stages in decision making in adopting an innovation as knowledge, persuasion, decision, implementation and confirmation "this helps an individual to reduce the level of uncertainty about the advantage and disadvantage of that technology" (Rogers, 2003). Many researchers used the Diffusion of Innovations theory to shape the conceptual framework and implementation design of international rural development programs.



Source: Diffusion of Innovations, Fifth Edition by Everett M. Rogers, 2003, p. 114

Figure 2. 4. A Model of Five Stages in the Innovation-Decision Process

Rate of adoption was the key future for Rogers adoption theory and he develop adopter categories to measure innovativeness of adopters (for his case farmers) to produce a statistical model and shown it on the normal distribution curve (Sahine, 2006). His classification includes innovators, early adopters, early majority, late majority, and laggards. In each adopter category, individuals are similar in terms of their innovativeness: “Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system” (Rogers, 2003).



Source: Ismail sahin, Iowa State University, 2006, p. 7

Figure 2. 5. Adopter Categorization on the Basis of Innovativeness

Sahine (2006) puts Rogers's definition of each stages of innovativeness as "innovators are those who are willing to experience new ideas", early adopters are "more limited to boundary of the social system", early majority have a good interaction with other members of the social system, but they do not have the leadership role that early adopters have. However, their interpersonal networks are still important in the innovation-diffusion process, Late majority are similar to the early majority but they include one-third of all members of the social system who wait until most of their peers adopt the innovation, Laggards have the traditional view and they are more skeptical about innovations and change agents than the late majority.

Even if there are a lot of researches conducted by applying Rogers's theory of diffusion of innovation, there are some publicized criticisms on the model. Some limitations of the theory have been described by Rogers himself (Rogers, 2003) A Pro-Innovation Bias, Individual-Blame Bias, Issue of Equality, Bias in Favor of Larger and Wealthier Farmers are some of the limitations on the assumptions taken for developing the frame work.

2.2.4 Bass Model

Bass model is by far the most common diffusion model used in marketing and it is a mixed model capturing both innovative and imitative effects (Ismail &Abu, 2013). The effects are diffusion channels according to the model the adopters are divided as innovator and imitator (Tae-Hyung et.al, 2012) those innovators are influenced to use the product by external factor like advertising and imitator are users of the product by adopting from the innovators (interpersonal influences) or word of mouse effect. The model has the probability that a certain consumer will make an initial purchase at a given time t given that no purchase has been yet made by that specific consumer. Also, the model assumes an adoption as a first-time purchase of a product (including services) or the first-time uses of an innovation (Bass, 1969). The mathematical formulation of the model with different parameters is as shown below

$$F\ t\ = 1 - \frac{e^{-\ p+q\ t}}{1 + \frac{q}{p} * e^{-\ p+q\ t}}$$

Where: F(t) – technology adoption / product purchase at a given time t

P – coefficient of innovation

q – coefficient of imitation

Bass diffusion model is simple enough to allow a first assessment without the need for further complex modeling. Rui and Lan (2012) and Kim et al. (2009) applied Bass model to show the forecast of how new product is diffused in the market or population and the result shows that Bass model is suitable for accurate fitting and forecasting the diffusion of products. The model can forecast a long-term diffusion pattern as (1) the firm has recently introduced the technology and has observed its diffusion for a few time periods or (2) the firm has not yet introduced the product or technology, but its market behavior is likely to be no changed to some existing products or technologies whose adoption pattern is known (Ismail &Abu, 2013).

Once looking at the diffusion models extensively, it is important to look at different tools used to analyze the data. Among them analytical hierarchy process and agent based modeling are reviewed.

2.3 Analytical Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty (Saaty, 2008). It is a theory of measurement through pairwise comparisons and depends on the judgements of experts to derive priority scales. There will be a scale of absolute judgments based on the given attributes in order to compare how much more, one element dominates another with respect to a given attribute. According to Saaty (2008) all information gained are not important to make judgment and peoples believe that the larger the quantity of data, the better result will, bee gained. He overcome this idea as by explaining too much information is as weak as too small information. Saaty (2008) puts the following steps to make a decision in an organized way to generate priorities one needs to decompose the decision into the following steps.

1. Define the problem and determine the kind of knowledge sought.
2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level is obtained.

There are a lot of researches conducted through using AHP as a decision-making tool especially on supplier selection. Handfield et. al, (2002) apply AHP in order to evaluate suppliers by considering the relative importance of various environmental dimensions and they examine how AHP can be incorporated into a comprehensive information system supporting environmentally Conscious Purchasing.

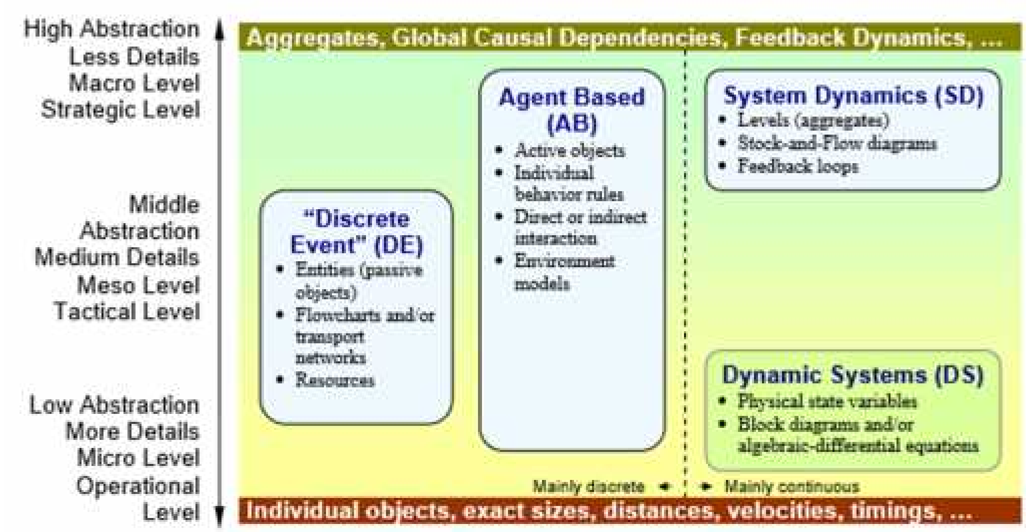
2.4. Agent - Based Modeling

Agent based model is a powerful simulation modeling technique used to model complex adaptive systems. It has been used in different disciplines including engineering, natural sciences, management and economics (Zhang & Zhang, 2007). After its application briefly introduced, different areas of application were implemented using real-world phenomenon like, flow simulation, organizational simulation, market simulation, and diffusion simulation (Bonabeau, 2002).

2.4.1 Benefits of Agent -Based Modeling

ME. Schramm et al. (2010) indicate several advantages of ABM by comparing to other simulation models for instance, it models complex system using the unit of study as individuals (agents) but in other models the unit of study is the population it also incorporates system heterogeneity through defining multiple agent types representing entities with different roles in the system. The other major feature they putted is its ability for simulating interaction among agents. In real world agents in the system often interacts and this interaction results a change.

Many literatures captured the benefits of ABM over other modeling techniques in three statements: ABM captures emergent phenomena, provides a natural description of a system and is flexible. It is clear that the ability of ABM to deal with emergent phenomena is what drives the other benefits (Bonabeau, 2002). Agent-based methods can be applied in both building theory and as a tool to analyze real world scenarios, support management decisions and obtain policy recommendations (Kiesling et al., 2009). ABM gives more deep insight for the system being modeled since it adds some futures on system dynamics and discrete event modeling (Borshchev and Filippov, 2004). In the figure below the different paradigms between discrete event, agent based and system dynamics is shown.



Source: Andrei Borshchev & Alexei Filippov oxford university England, 2004

Figure 2. 6. Approaches (Paradigms) in Simulation Modeling on Abstraction Level Scale

2.4.2 Agent- Based Diffusion Model

ABM advances and strengthen diffusion research in different perspective both for macro and micro level analysis in technology diffusion studies which is to mean adoption and diffusion respectively (Ting Zhang et al., 2011). Kiesling et al. (2009) examine the strengths and limitations of agent-based modeling in the context of innovation di usion, discuss new insights agent-based models have provided. In the context of diffusion ABM applies to cases where people are influenced by their social context, that is, what others around them do (Bonabeau, 2002). Many researchers use agent-based model to study the diffusion of technology Rai and Robinson (2015) developed theoretically based and empirically driven agent-based model to study energy technology adoption through integrating social behavioral, economic and environmental factors. Also Ting Zhang et al., (2011) apply agent-based model to investigate factors that can speed the diffusion of eco-innovations, the Diffusion of Alternative Fuel Vehicles and they get the result from Simulation that technology push can be an important mechanism for speeding the diffusion of AFVs.

Table 2. 1. Comparison of Different Technology Diffusion Models

No	Technology diffusion models	Strength	Weakness
1	Epidemic model	➢ A good starting point to think of equilibrium ➢ Puts the time path or rate of adoption as S curve which is not changed even on recent models (Arthur, 1989) ➢ Explain the importance of **information** diffusion for technology diffusion (Karshenas and Stonman, 1993)	➢ The major weakness is on the **assumptions** taken (Rao and Kishore, 2010) those are • "Once potential adopters learn of a technology; they will use it". • "The quality of the technology is the same over time" ➢ Doesn't consider differences among users means that it focuses on aggregate industry rather than individual firm's adoption decision (Reinganum, 1981a) ➢ Disequilibrium mechanism (Baptista, 2000) ➢ Potential adopters are considered as passive recipient rather than active seeker
2	Probit model	➢ Accelerate information diffusion or help suppliers of the technology to fly down their learning curve which builds the human capital (Geroski, 2000). ➢ Consider important characteristics that differs potential users of the technology ➢ Rank firms based on the benefit gained from adoption ➢ Indicates there should be a cost incurred by the firm for adoption and diffusion (Sarkar, 1998)	➢ Assumes that there is information on that technology. What slows the diffusion or make difference is the firms adoption strategy (Baptista, 2000) ➢ It points to the firms themselves as the source of the problem if there is a problem. Firms often need to acquire special skills and they may lack enough incentives to move quickly (Geroski, 2000).

3	Game theoretic model or Stock model	➢ Focuses to equilibrate firms benefit from adopting that technology (Reinganum, 1981a) ➢ Shows the effect of density dependent technology diffusion ➢ Shows the way for searching the effects of spreading usage of new technology within a minimum time span	➢ Not relaxed assumptions like firms should pay equal cost for adoption, information on technology is perfect ➢ Strategic interaction of firms and there should be a precondition to adopt a new technology at similar time (David and Olsen, 1992). ➢ Focused the negative externality of adoption decision since it says as the number of potential adopters increase the gross benefit gained from will decrease (Karashenas and Stoneman, 1993).
4	Order model	➢ Goes further on stock model and concludes that there is a tradeoff between higher cost of early adoption and higher return gained because of early adoption (Sarkar, 1998) ➢ Elaborate the process of Legitimation and competition between firms of new technology	➢ Highly concerned on the profitability or cost issue of adoption rather there are other things which can be seen equally as cost, like firm's long term advantage of that technology and even reputation.
5	Rogers's model	➢ Rogers theory is a widely used theoretical framework in the area of technology diffusion and adoption (Sahine, 2006) ➢ Point out the main characteristics of the technology that determines the response by the end users (Rogers, 2003) ➢ He develops adopter categories (Rogers, 2003)	➢ Innovations are being targeted to the "Innovators" and "Early Adopters" (Michael, 2015) ➢ There is the implication that an innovation should be diffused and adopted by all users (Lee, 2004) ➢ Divides rural communities and not benefitting or assisting those in most need (Rogers, 2003)

Once looking at each model and comparing them by listing out their importance or strength and weakness then it will be easy to decide which model is more compatible for the specific research case. On the table below sample of the articles are summarized for the application of technology diffusion models in different sectors.

Table 2. 2. Application Areas of Major Diffusion Models

Author	**Model**	**Application**
(Lund, 2005)	Epidemic diffusion model	To study the market penetration rates of new energy technologies
(Ting-Ting Lee, 2004)	Rogers model	To analyze nurses' perceptions toward using a computerized care plan system
(Wine & Michaell, n.d)	Rogers model	Adoption of electronic comers by SMEs
(Derya & Aysit, 2015)	Rank or Probit model	Examines the impact of firm resources on ICT adoption by the Turkish business enterprises
(Brychan, 2000)	Bass Norton model	Model technology diffusion in to SMEs including external sources and channels.
(Rui and Lan, 2012)	Bass diffusion model	To forecast the number of mobile phone in China. They estimate the trend of adoption of mobile phones using Bass diffusion model.

2.3 Industrial Cluster (IC)

Industrial cluster is generally defined as the "geographic concentration of economic activities within a certain sector producing similar and closely related goods". Clustering can be shown in two different dimensions which are functional dimensions and physical dimensions (UNIDO, 2016) when we say functional dimensions of clustering it has two linkages one is the linkage or integration of enterprises with buyers of the final product and the suppliers of raw material or input and the other is inter firm integration or linkage among enterprises. This idea can be strengthened as Industrial clusters are those group of establishments geographically concentrated, which either share a common set of raw materials needed or rely on each other as supplier or customer (Pan and Zhou, 2009). And the physical dimension is just their location proximity or being close to each other for different purposes. One can also notice that while 'specific region' provides a geographical dimension to the definition of a cluster 'related industries' adds a technological dimension. It implies that the groups of firms are similar in products or processes and are linked through the technology supply chain (Basant, 2002).

One can also look the connection of industrial clusters as downstream which includes final product buyers or consumers and also upstream which includes all suppliers of raw materials (Netsanet, 2014).The organization of an industrial cluster is not only include a core value system that includes suppliers, competitors, customers and associated enterprises of industry, rather an important part which plays a great role for the effectiveness of the above chain or value system or a support value system that includes universities, research institutions, local governments, industry associations, financial institutions and intermediary organizations of science and technology (Wei and Xue, 2010).

The sources of the technology can be shown in two dimensions the one is inter-firm technology transfer and sharing of knowledge and technology with each other and the other is higher education institutes. The critical issue here is that these enterprises should have a strong linkage with the universities and research institutions since they will upgrade their performance by using an important research and developments from those institutions. Since Without technical innovation, the scale of the industry cluster cannot be expanded, the competitiveness of the industrial cluster cannot be enhanced and also the development of the industrial cluster cannot be sustained (Wei and Xue, 2010)

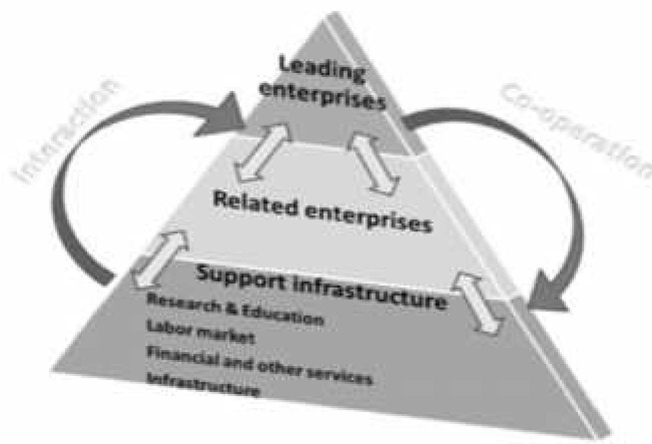
2.3.1 Integration of Industrial Clusters

The concept of industrial clusters clearly differs from simple geographic agglomeration in that putting them together as a cluster is not simply for the proximity of each other but for the integration of knowledge and information technology (Morosini, 2004). The major concern behind industrial clusters is that how the new and existing technology can be shared and integrated to those close proxy firms or enterprises in order to provide quality product and service. Sometimes around the world especially on the developed world it is common to see those large international and multinational firms when losing their part on the value chain of important areas like research and development, manufacturing and product design because of the strong interaction and integration of small and medium enterprises occupied as a cluster (Morosini, 2004).

He also depicts some points regarding knowledge integration of industrial clusters they are "industrial clusters are social entities and geographic closeness is very important for their integration". In my argument an integration of industrial cluster has a vital importance because things like product, technological knowledge and market can easily be shared between those closely located firms rather than those which are dispersed. As more researchers argued that inter-firm interaction or vertical integration is more relevant for their competitiveness. Cluster environments may differ since there is an integration between companies producing the same products as well cooperating with the suppliers and supporting entities (Kassalis, 2011).

When thinking of knowledge or technology flow through informal contact, it may seems difficult since the employees have to be loyal to that firm which means the information of the firm should be kept secured in order to minimize imitation Dhal and Pedersen(2004) studied this scenario on their research paper of knowledge flow through informal contact in industrial cluster and found a result of Informal contacts are important sources of knowledge for the engineers in their daily working life inside the cluster it is an important factor for knowledge diffusion(Dhal and Pedersen, 2004). This idea can be strengthened by other researches as the purpose of clustering enterprises is not for the matter of being close each other geographically but also to be integrated and social interaction can play an important role (Morosini, 2004).

An integration of enterprises is not only with each other but also with all stockholders and the society this clusters are obligated to cooperate in social responsibilities sine the problem happened in the society directly or indirectly affects the enterprises (Battaglia et.al., 2010) the researchers develop a strong idea that enterprises under the cluster should have a formalized corporate social responsibility since their success and competitiveness related with the social community.



Source: Ivars kassalis, University of Latvia, 2011

Figure 2. 7. Integration and Cooperation within and out of the cluster

Silvestre and Netob studied mining cluster in Brazil and the major problem they identified is that because of absence of framework that considers the dynamic nature and challenges of clusters they develop a framework which will encountered the dynamic nature of clusters and also identify the challenges like lack of coordination of the enterprises and stakeholders and also misaligned policy approach. Here we can understand that in any way coordination and integration among enterprises of the cluster is a critical way to be technologically capable and competent (Silvestre and Netob, 2013).

2.3.2 Industrial Cluster in Ethiopia

The formation of industrial clusters in Ethiopia is as a form of natural clusters and government created clusters (UNIDO, 2016). Those natural clusters are those created without any influence of government and are gradually clustered enterprises. UNIDO is playing an important role for the development of small, medium and large enterprises in Ethiopia by supporting them in all dimensions. UNIDO introduced a cluster development program in leather and leather products, textiles and garments and metal and wood sectors (Netsanet, 2014). According to Mr. Getahune, the Information Directorate of the Federal Small and Medium Enterprises Development Agency "The level of the enterprises depends on the capital they acquire and the labor force they have and time by time they will be graduated up from their level based on their performance".

2.3.3 Small and Medium Enterprises

Defining small and medium enterprises is difficult since they have different criterion in different countries. "SMEs as a formal enterprise with annual turnover, in U.S. dollar terms, of between 10 and 1000 times the mean per capita gross national income, at purchasing power parity, of the country in which it operates" (Tom and Van der, 2008). Small and medium enterprises have very heterogeneous sizes and organizational structures. They are mostly owner-managed and not very bureaucratic out of necessity to solve day-to-day problems since their organization is based on cooperation.

The role of SMEs differs according to the economic situation of the specific country which means in some countries almost all of the economic activities are directly or indirectly affected by the performance of the small and medium enterprises. "For example, in Japan, almost 90 percent of all employment and about two-thirds of manufacturing employment is in SMEs the other case is Italy, SME employment share, on both counts, is comparably high. Looking at the United States, SMEs comprise about 60 percent of all employment and just over one-third of manufacturing jobs" (Shapira and Rosenfeld, n.d) in any case they play an important role for the growth of the country. They have similar financial turnover and informal relations and communication process. They recognize the importance of interpersonal relationships and have a high interrelation with the local community and the local environment (Battaglia, et.al, 2010). Beside their role for the economic growth of the country they have face challenges that of lack of technological and financial resources that makes them unable to be the source of the technology by themselves and even unable to absorb the technology from outside and diffuse it (Brychan).

Since the definition of SMEs is different accordingly, which means it can be defined by international institutions, national lows and even by the industry, numbering is the most suitable language used to define them (Amare, 2017) number of employees, total asset and annual sales are the most suitable attributes to define micro, small and medium enterprises.

Table 2. 3. Definition of SMEs by World Bank

Enterprise indicator	Number of employees	Total asset	Total annual sales
Medium	>50; ≤300	>$3,000,000; ≤$15,000,000	>$3,300,000; ≤$15,000,000
Small	>10; ≤50	>$100.000; ≤$3,000,000	>$100,000; ≤$3,000,000
Micro	<10	≤$100,000	≤$100,000

Source: Tom and Van der, 2008

2.3.4 Small and Medium Enterprises in Ethiopia

Small and Medium scale Enterprises (SMEs) are regarded as the engine of economic growth and equitable development in developing economies of the country and the subsector constitutes the major share in terms of number on earlier years Ethiopia has defined the sector based on the total asset the enterprises acquired and later the country revised the definition at least to aligned with international definition and revised by considering other attributes (Worku, 2011) in addition the definition also segregate the manufacturing and services enterprises. However, there is still confusion among different governmental organization on the definition. On the other hand, the definition gives more emphasis for micro and small enterprises, there is no clear demarcation putted for small and medium and medium and large enterprises (Amare, 2017).

Central Statistics Agency (CSA) had grouped both large and Medium Enterprises together when these enterprises have employed more than 10 employees and used automated machinery. The definition focuses more on automation since it will minimize the number of employees needed and ignored the total asset. Federal Micro and Small Enterprises Development Agency (FeMSEDA), on the other hand, put definition of Micro and Small-Scale Enterprises and categorize them from support provision perspective which contempt Medium Enterprises (Etagegn et. Al, 2015). A small enterprise in the industrial sector is one which operates with between 6 to 30 persons and/or has paid up capital or total assets not exceeding Birr 1.5 million.

Similarly, a small service sector enterprise is one that has between 6 and 30 persons and/or has total assets or paid up capital of Birr 500,000 and for medium enterprises the total asset is 1.5 million birr and the number of employees is above 30 up to 100 the data found doesn't distinguish the service and manufacturing sector for the medium enterprise (Annual statistical bulletin, 2011-2015).

Table 2. 4. Definitions of Small and Medium Enterprises in Ethiopia

Type of enterprises	Sector	Manpower	Total asset
Small enterprise	Manufacturing	6-30	≤birr 1.5 million
	Service	6-30	≤birr 500,000
Medium enterprise	Manufacturing	30-100	1.5-20 million

Source: Annual statistical bulletin, 2011-2015, (2016 final)

As compare to the definition of the World Bank which is an average of the international level, there is a very visible gap with the Ethiopian current definition regarding working capital and human capital of small and medium enterprise resulted from the economic statues of the country.

2.4. Literature Summary

From the journal articles and books reviewed conclusion is given here. From the models of technology diffusion discussed, it is understood that on different time different researchers contribute to the research area (technology diffusion model) as product and process diffusion models by designing General vs. Domain specific, Conceptual vs. Mathematical, Focus on innovation vs. adopters, Organizational vs. Individual, Process vs. Outcome, Proximity vs. Network and Rate-oriented vs. Threshold.

The early Epidemic model is the first diffusion model based on information diffusion and it doesn't consider the economic equilibrium. Then after, Probit model stock model, order model and game theoretic model comes with some modification made and are called equilibrium technology diffusion models. These models consider the heterogeneity or capacity of adopters and assumes that the firm should pay a cost to adopt a technology. In each model there are new futures added which were not considered in early models. For example, Probit model assumes that since the users of the technology have different capacity and willingness to accept or adopt the technology, the firm should pay a cost. Then later on the stock model the effect of the spread of the technology is included. Again on the order model, early adopters are more benefited from the technology than lagers. Rogers and Bass models focused on Product diffusion and by categorizing adopters as early adopters and laggards.

As a conclusion, Models of technology diffusion and the importance of integration of industrial clusters were major areas of the review. In the tally sheet shown below the focus areas of the review with respect to the share of total articles is summarized.

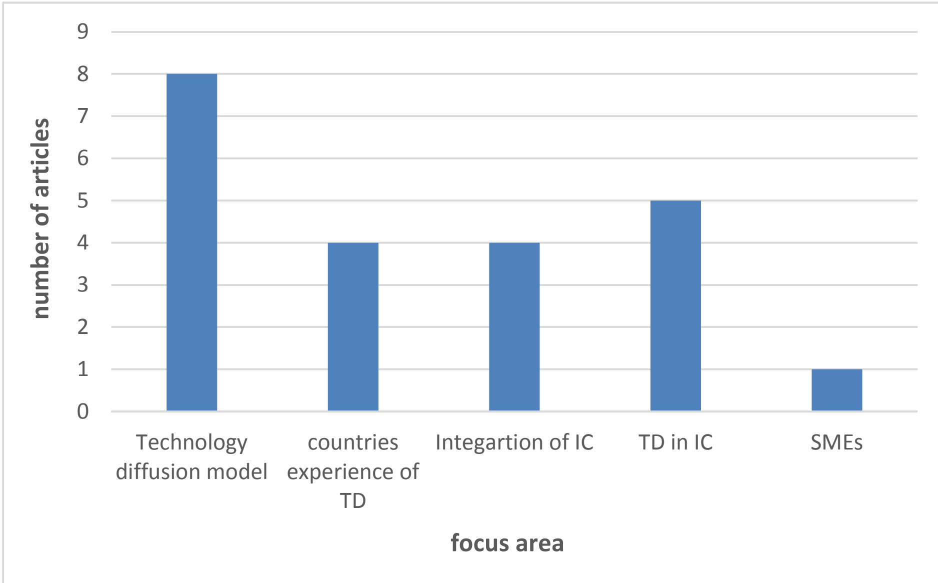


Figure 2. 8. Specific focus areas of the selected articles

2.5 Literature Gap

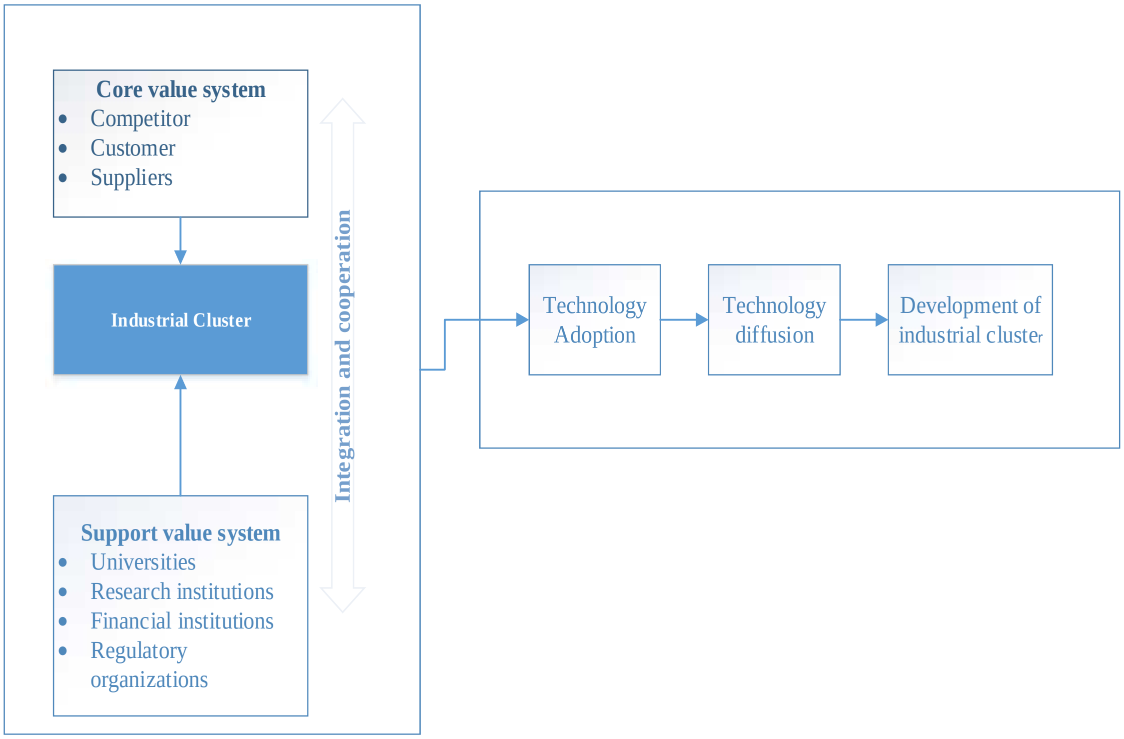
The following major gapes are pointed out from the literatures reviewed.

- The diffusion models reviewed are mainly based on the diffusion of one specific technology showing the rate of diffusion within the specific target group. However, few researches are on the technology diffusion that is based on the integrated participation of enterprises, universities, research institutions, local governments, industry associations, financial institutions and regulatory organizations. (supporting strategies for adoption of technology was not included)
- Almost all literatures reviewed regarding modeling technology diffusion are concerned on the adoption and diffusion of new technology or best practice except Thomas Brychan (2000) he considers on his model how low activities or non-value adding activities should be eliminated (selection of technology).
- There are different assumptions taken to construct the models. In each assumption there are issues which will be difficult to directly apply on the real scenarios of an enterprise.

2.5 Technology Diffusion in Industrial Clusters (Conceptual Frame Work)

From the data gained during preliminary visit of industrial clusters in Addis Ababa and from the responses of personnel of FeSMEs development agency and Addis Ababa city industry development office, the constraint for industrial clusters development is of mainly related with technological capability and giving less attention to be technologically competent and also their technology adoption strategy. Taking theoretical Considerations of “Probit and Epidemic” models i.e. heterogeneity of adopters and information diffusions respectively, conceptual frame work is developed to customize with industrial clusters of Addis Ababa which is a “cooperation model of technology diffusion” combines two participants enterprise and support institutes in and out of the industry cluster (universities, research institutions, local government, financial institutions and intermediately organizations of science and technology).

In the process of technology diffusion, local government creates a favorable institutional environment by providing policy support; science and technology intermediary organizations improves the success rate of the transfer by effectively connecting universities, research institutes, enterprises and government; universities supports enterprises by providing R&Ds or innovations and trainings; financial institutions realize the combination of the different subjects by providing an effective capital supply. In the collaborative support ofr local government, industry associations, financial institutions and intermediary organizations of science and technology, all the members can join in the technology adoption and diffusion with their advantageous resources. By the participation of all these members, the absorptive capacity, capability of adopting technologies will be enhanced, by this faster diffusion of technology will be accelerated and the development of the industry cluster will be faster and integrated.



Source: Owen, 2017

Figure 2. 9. Conceptual frame work for cooperation of enterprises with the support value system

Chapter Three
Research Design and Methodology

This chapter explains in detail the general design of the research and the methods used for data collection and analysis. It includes three main parts. The first gives a highlight about the research design; the second discusses about qualitative and quantitative data collection methods; and the last illustrates the data analysis method and tools

3.1 Research Design

The research design is intended to provide an appropriate framework for the study. It is a detailed plan used to guide the research based on achieving its objectives. A very significant decision in research design process is the choice to be made regarding the research approach. The research approach followed for the purpose of this research is inductive According to this approach research begins with specific observation of some problem which is used to draw generalized theories and conclusions from the research while it is also most appropriate for exploring new phenomena or looking at previously researched phenomena from a different perspective. The reason for occupying inductive approach is the specific gap realized in the industrial clusters of Addis regarding integration and diffusion of technology.

The overall research design includes literature review, data collection, analysis, result presentation and interpretation, validation, conclusion and recommendation and the future research direction. The research design tree is developed as shown in figure below.

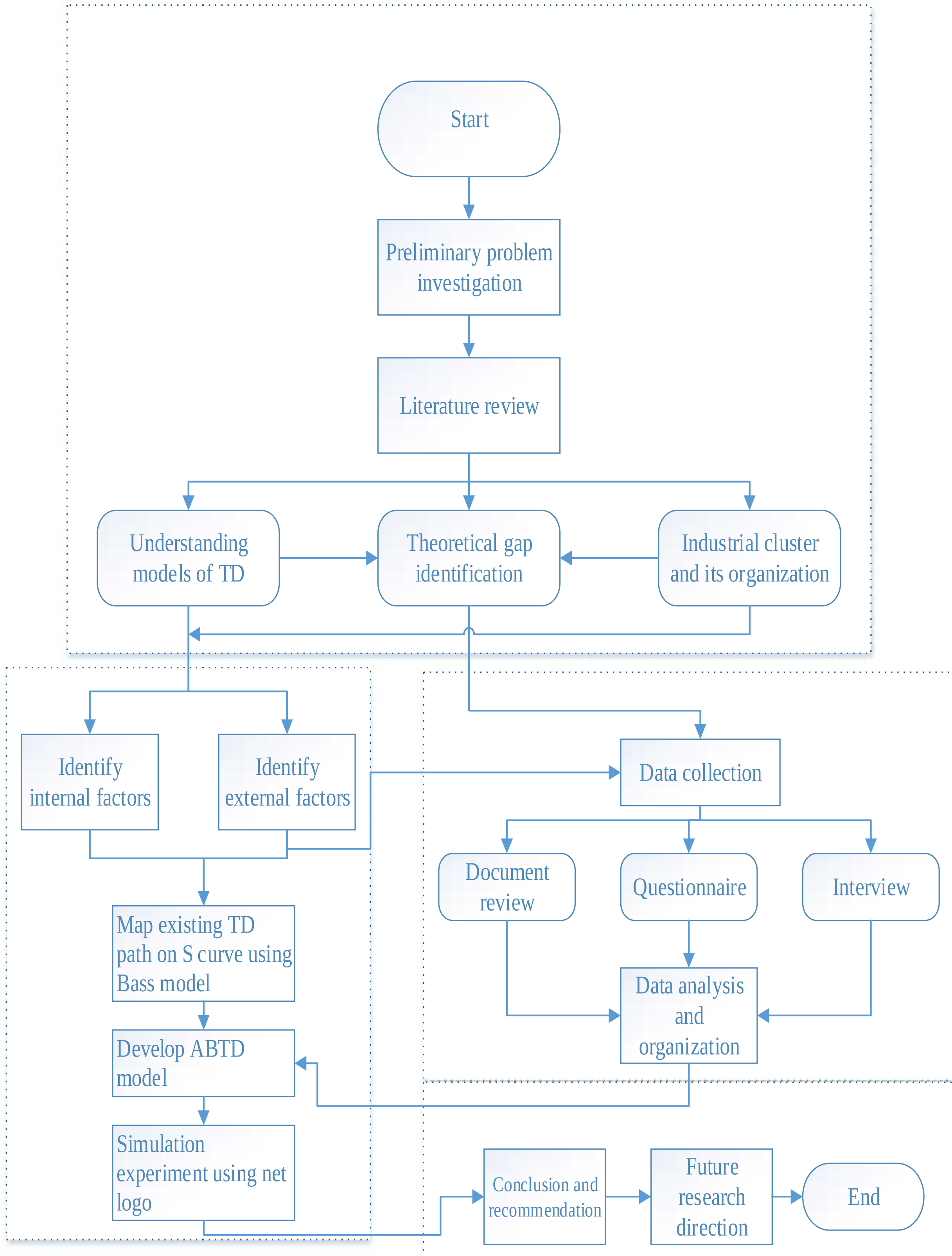


Figure 3. 1. Research design tree

3.2 Research Methodology

To address the key research objectives, this research used both qualitative and quantitative methods and a combination of primary and secondary sources. The different methods used are explained below:

3.2.1 Literature Review

To achieve the research objectives, extensive literature review which is hovering around different theoretical knowledge that are important for this research regarding models of technology diffusion, Industrial Cluster (IC) and integration of industrial clusters was conducted. In order to understand the research area in detail, the literature review starts from looking the international view of technology diffusion then the case of developing countries. Different types of technology diffusion models were the major parts of the literature and comparison of the models was done to understand the strength and weakness of each models. Finally, different literatures about industrial clusters and their integration ware reviewed. Moreover, the articles reviewed are summarized on the table by listing out the problem, methodology used and the gap seen.

From the articles reviewed some important points are reached out. Since the objective of the research is to model platform for technology diffusion for industrial clusters, to include supporting strategy for enterprises technology adoption.

3.2.2 Study Area Selection

The research is undertaken on clustered medium scale manufacturing enterprises. Since an intention should be given to the sector and because the sector's competitiveness directly related with technology utilization. The productivity of the manufacturing firm depends on its technological capability (Morosini, 2004). In addition, behind the firm's advancement of producing a product with new type or better-quality standard, there is an addition of disembodied or embodied technology.

According to the information found from Addis Ababa city industry development office, medium scale manufacturing enterprises are currently working on 8 different manufacturing sub sectors those are;

- Textile and garment
- Leather and leather products
- Food processing and beverage
- Chemical and pharmaceutical
- Metal works and engineering
- Wood works including
- furniture and ornaments service and
- Agro-processing

From the survey of assessment of clusters in Ethiopia the largest clustering of firms appears to be in Addis Ababa. And the largest share of output in the location relative to total country wide manufacturing output almost three quarters of output (74 percent) are produced in Addis Ababa. From the very recent data set, there are around 634 small enterprises working on different sectors of listed above and 950 medium enterprises. Among those 950 medium enterprises about 800 are of those graduated from small enterprises and supported by the government the rest 150 are working privately which directly enter in to the business by taking investment license from the government.

The exact number of clusters of these enterprises is not clearly defined or geographical proximity of the firms is not standardized. There are some enterprises which are located close to each other in different way of organization some of the government created clusters are work on the shad and the others located together in industry mender and even some of them are distributed without clustering. Since there is a time constraint to cover all the subsectors under the manufacturing sector inside the analysis, one subsector is selected using waiting factor analysis by listing out different decision-making factors or criterions. The criterions identified are

- Level of technology utilization
- Level of export market or market share
- Number of enterprises in the sector
- Level of human capital utilized
- Level of integration with industry extension

- Level of integration with research institutions
- Level of integration with learning institutions and Proximity of enterprises

The subjective qualitative judgment is taken from preliminary interview with experts of Addis Ababa city industry development office and converted in to quantitative data then using weighing factor analysis one subsector is selected.

Table 3. 1. Weighing factor analysis for each manufacturing subsector

Decision **f**actors	weight	textile	leather	Food	chemical	metal	wood	furniture	Agro processing
Technology intensivist	0.1	60	65	60	65	40	55	55	50
Number of enterprises in the sector	0.05	75	80	50	60	60	55	65	55
Human capital utilization	0.1	40	55	50	55	35	35	35	35
Collaboration with research institutions	0.2	35	30	45	45	35	35	35	45
Collaboration with learning institutions	0.2	35	35	40	55	35	35	30	40
Collaboration with financial institutions	0.1	60	65	60	60	60	60	60	65
Market share	0.05	55	80	60	55	55	50	60	60
Proximity of enterprises	0.2	50	80	45	45	60	65	65	45
Total weights		45.6	59.25	48.5	52.75	45.25	47.25	47.25	46.75

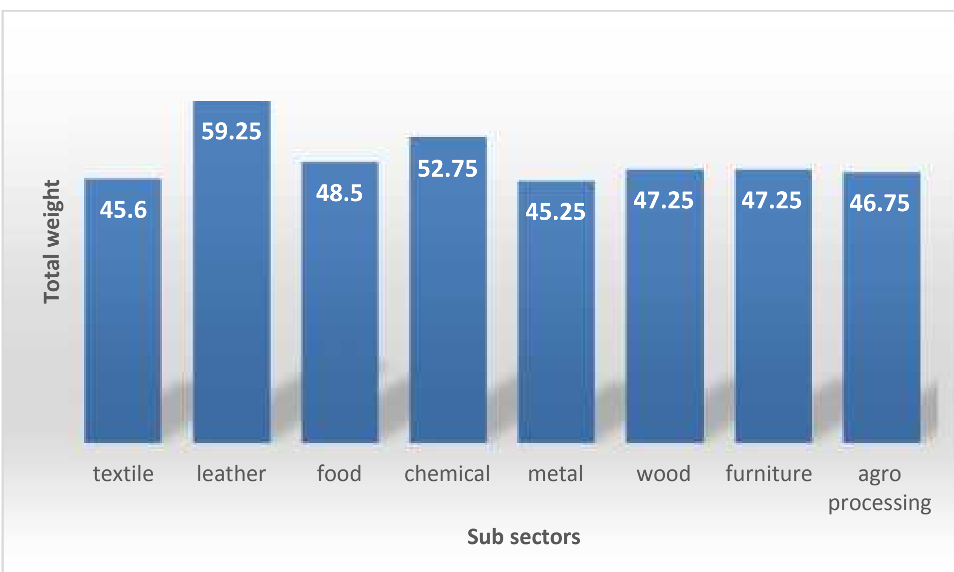


Figure 3. 2. Weighted result for each manufacturing subsectors

As one can see from the above analysis, leather product subsector is with the highest weight. As a result, leather and leather goods manufacturing subsector is selected. Under this manufacturing subsector, Ethio - international footwear cluster cooperative society EIFCCOS is taken as a case.

3.2.3 Data Collection and Source of Data

The type of data collected is both qualitative and quantitative this type of data collection method is selected because it helps to capture both process and outcome results and also strengthen the analysis. The source of data is both primary and secondary. The secondary data were collected mainly from journal articles, books, annual statistical reports and online data bases. Similarly, primary data relevant to the research in achieving its objective were collected through semi structured questioner and semi structured face to face interview with respondent.

Questionnaire:

Semi structured questionnaire is prepared by classifying the respondents as owners and employees of an enterprise in order to fulfill the required data. The purpose of the questioner is to measure each independent variable of the influencing factors pointed out from the secondary data set.

Interview:

Semi structured interview was held with the management of supporting organizations in order to understand the level of cooperation with the enterprises. Key informants were selected from;

- Leather industry development institute
- Industry extension office
- Addis Ababa institute of technology university industry linkage (AAiT-UIL)
- Federal small and medium enterprises development agency
- Development bank of Ethiopia
- Addis Ababa industry development office

The above three (Research institutions of selected subsector, Industry extension office, Addis Ababa institute of technology university industry linkage (AAiT-UIL)) were interviewed to understand the level of support through R&D and trainings. The next two (Federal small and medium enterprises development agency and Development bank of Ethiopia) were interviewed to identify the issues related to government policy, regulation and financial affairs. Final interview was with Addis Ababa industry office since it is the responsible organization about the 634 small and 950 medium manufacturing enterprises found in Addis Ababa.

Table 3. 2. Summary of Primary Data Collection Method

No	Tool	Source of data	Importance
1	Questionnaire	Owners or management personnel of selected enterprises	To measure the variables or influencing factors for TD identified as behavior of firms and technology attributes Pair wise comparison for each internal and external factor
		Employees of selected enterprises	To measure the variables identified as employee behavior
2	Interview	Leather industry development institute (LIDI), Industry extension office and Addis Ababa institute of technology university industry linkage (AAiT-UIL)	To measure the external support related to R&D, trainings and technical supports
		Federal small and medium enterprises development agency and Addis Ababa industry office	To measure the external support related to government policy and regulatory issues
		Development bank of Ethiopia	To measure external support related to financial provision

3.2.4 Data Analysis Methods and Tools

Data analysis and organization is classified in to three major parts. These are understanding the existing rate of technology diffusion, prioritizing internal and external factors affecting technology diffusion and development and validation of the model.

I. Understanding the existing rate of technology diffusion

Mapping the existing path or rate of technology diffusion was the first task. Integration of enterprises and their cooperation with the support value system is elaborated theoretically and converted in to quantitative result in order to estimate the coefficient factors of imitation and innovation. Then to show the rate of adoption of technology based on the existing trend, BASS diffusion model is implemented and forecast the diffusion rate of HDSM (technology) and the rate on is shown on S curve.

II. Prioritizing internal and external factors affecting technology adoption and diffusion

After looking at the existing rate of diffusion of technology, the variables (identified from the literature review) and measured through interview and questionnaire with an intention of assessing internal and external factors that affect adoption and diffusion of technology, the significant factors are prioritized using AHP. The prioritized factors are directly used as an input to define agents.

III. Model development and validation

Considering those high priority factors both from internal and external perspective, Agent based model of technology diffusion is developed. First the model is framed on theoretical perspective with the domain of three point these are defining agents, designing agent's interaction and communication topology and the last one designing agent's adoption decision. On the agent's adoption decision some uncertain conditions were needed to be considered both for imitator and innovator agents with an intension of substituting binary adoption decision (adopt or not adopt) in to a fuzzy set. To do so, fuzzy set computation is done using TFN analysis taking of the above prioritized internal and external factors.

Validation of the model is done using simulation technique on NETLOGO which uses programing language to construct the code. The simulation result allows enterprises and supporting organizations to get insight into the causal factors influencing enterprises adoption decision and also the potential technology diffusion rate resulting from the influencing factors. Using net logo, the existing scenario is simulated and additionally, simulation experiment is takes placed on three scenarios. On the table below the tools used, inputs, and outputs are summarized.

Table 3. 3. Summary of Data Analysis Method and Tools

No	Tools	Input variables	Outcome	Reason to use
1	Weighting factor	Important criterions or factors of each sub sectors	High weighted subsector	To select one subsector to be analyzed from the manufacturing sector
2	Bass Model	Survey of HDSM (technology) adopted or not by enterprises	Forecasted cumulative adoption of HDSM on S curve	To forecast the rate of TD in the cluster with the existing situation
3	AHP	Measured internal and external factors affecting TD from interview and questionnaire	High priority factor	To take as a parameter on the model and to simulate the result
4	TFN analysis	Prioritized factors using Likert scale	Triangular fuzzy set for agent's adoption decision	To put agent's adoption decision under fuzzy set
5	ABM	Used to develop model and Simulate the model		
NETLOGO 6.2.0 is the software used to simulate the model				

3.2.5. Results Conclusions and Recommendations

From the agent based model and simulation result, it is elaborated that the positive impact of cooperation of supporting organizations with enterprises and integration of enterprises with each other on the rate of adoption and diffusion of technology. From this some important conclusions and recommendations are made.

As a conclusion, medium scale manufacturing industries plays an important for the sustainable development of the country. Dealing with the technological capability development of these industries is vital. In general, cooperation with supporting organizations and internal integration is a critical landmark for faster adoption and diffusion of technologies in industrial clusters.

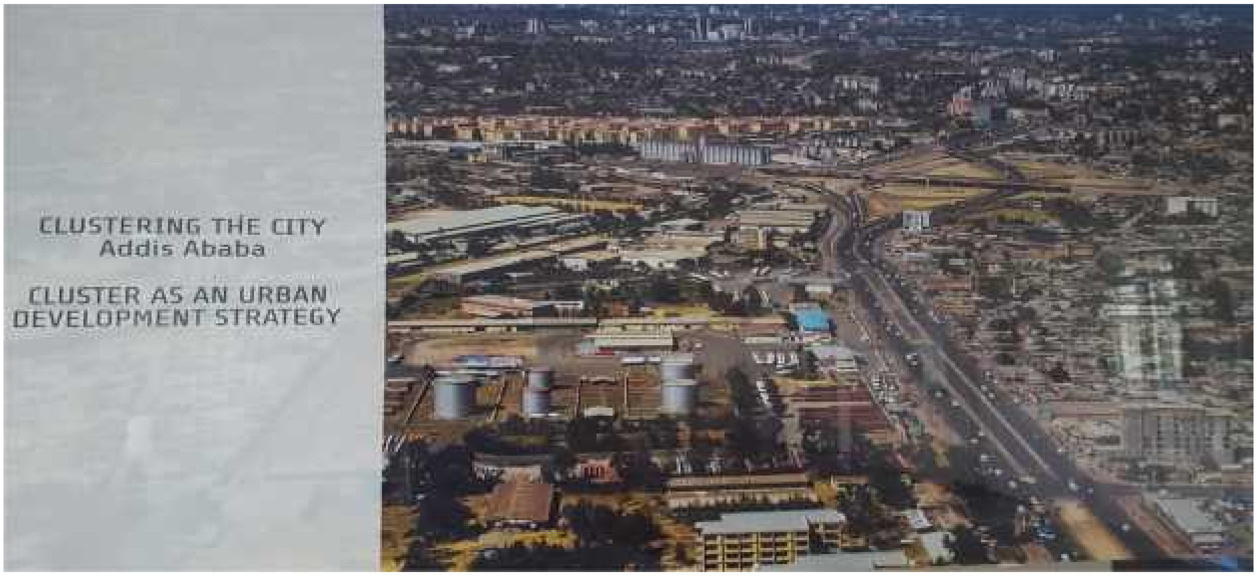
Finally, recommendations are forwarded for the concerned stakeholders on how adoption and diffusion of technology would be accelerated in industrial clusters. Furthermore, important future research directions are indicated.

Chapter Four
Data Analysis and Organization

In this chapter the overall existing trend of leather product manufacturing small and medium enterprises with respect to their integration with all the supporting value system and with competitor enterprises will be explained. The internal and external factors identified will be elaborated here with respect to the existing situation. To indicate the effect of internal and external influences of technology adoption, one specific technology which is important or value adding for the manufacturing process is taken in order to investigate the existing technology adoption path. To do so, Bass diffusion model is implemented since it is a potential model to forecast the adoption of technology within the specified target group. The specific cluster taken for case investigation is Ethio-International Footwear Cluster Cooperative Society Ltd (EIFCCOS) below the detail explanation of the cluster is presented.

4.1. Back Ground of Ethio-International Footwear Cluster Cooperative Society Ltd (EIFCCOS)

The footwear industry could be one of the most important manufacturing industries that would be the source of foreign currency saving and earning, through fully satisfied local shoe markets and having reasonable share in the international footwear market, as Ethiopia is largely blessed with abundant livestock. The industry however, has been in the very law level of development and has been facing more aggravated problem. Looking specifically clusters in urban area they can be one of the potential income generating strategy however, it is a lot to be done to increase the competitiveness of the clusters as well as the sector.



Source: AAIDO, 2018

Figure 4. 1. Cluster as urban development strategy

To change the prevailing problems, Ethio-International Footwear Cluster Cooperative Society Ltd was established by integrating about 1000 footwear and related material producers of Small and Medium enterprises under the proclamation for corporative society number 147/97, in Addis Ababa, on June 2006. EIFCCOS has organized those which have been formally and informally producing shoes and shoe related materials for the local market in disorganized and dispersed manner, based on legal agreements ultimately to be able to produce competitive and high-quality shoes through creating the highest possible level of integration and specialization among members. Objectives, mission and vision of EIFCCOS are presented below.

Objectives

- To create sustainable employment opportunities for over 100,000 people whereby the quality of their life along with their families could improve greatly
- To contribute the development of the export sector and to the foreign currency earning of Ethiopia, by producing high quality shoes for exports
- To positively impact the development of sectors ranging from the leather industry to livestock breeding, through the chain of demand effects that begins from demands for finished leather products

Vision

To make EIFCCOS the national leader in the production of modern and high-quality shoes, and one of the world class shoes producers in the future.

Mission

To integrate the traditional shoe producers and transform their production system to the very modern ones.

The **major leather products** produced inside the cluster are;

- Footwear including kids, gents and ladies
- Leather jackets
- Bags
- Belts and
- Industrial Gloves

Source: Author's own picture, 2018

Figure 4. 2. Leather products produced in EIFCCOS

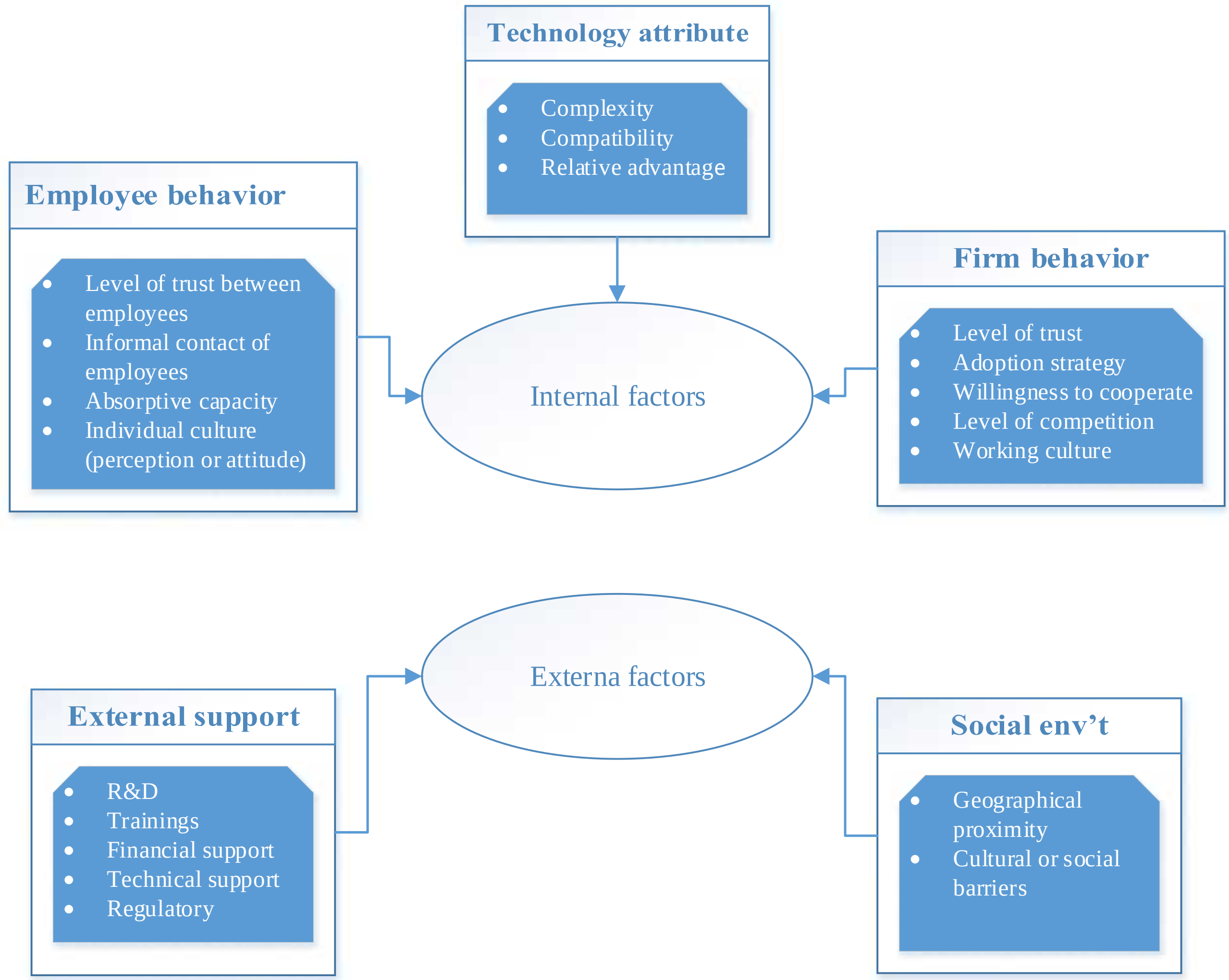
EIFCCOS is one of government created cluster legally governed under Addis Ababa industry development office and treated as Industry Zone. The cluster is located in Yeka sub city around Megenagna, in front of British Embassy. It has six G+4 blocks in each floor there are differently sized sheds for the purpose of manufacturing.

Currently the cluster has a total of 280 producers with different operating capacity. Here there is no clearly sated up profile about their current working capital. However, they are mixed of either small or medium level enterprises. In addition, there are raw material suppliers, retailers and designers inside the cluster which will provide an input for the producers and retail their finished goods.

As stated in the problem statement, the major problems for this SMEs organized as a cluster, is lack of integration, working together, sharing technology and external cooperation. Because of this their development is not integrated, some of them produce a quality product with a high market share and others not.

4.2. Factors (Variables) Affect Technology Adoption and Diffusion in Industrial Clusters

An enterprise may or may not adopt a technology for many reasons in this research, potential factors are identified from the literatures by classifying them as internal and external factors. Because the rate of diffusion of technology directly related to these influencing factors. When Frank M Bass formulates a mathematical equation to determine the rate of diffusion of technology, the important parameters he has considered was the coefficient of imitation and the coefficient of innovation. This coefficient factors are generated from the internal and external factors that affect adoption decision of an individual. Taking similar case, endogenous and exogenous factors putted below on the figure are identified based on considerations of the concepts of reviewed literatures and different data sources.



Source: Modified from Dhal and Pedersen 2004, Brychan 2000, and Morosini, 2004

Figure 4. 3. Factors affecting the rate of adoption and diffusion of technology in industrial cluster

4.3. Data Interpretation and Presentation

Important internal and external factors listed above, which are identified from the literatures reviewed are measured and elaborated in detail taking the case of EIFCCOS. Responses from the questionnaire (for internal factors) and interview (external factors) are discussed below.

4.3.1 Internal Factors

Internal factors are considered under three main categories: employee working culture, firm behavior and technology attributes. 10 employees and owners from 10 enterprises were selected to fill the questionnaire. The data collected from the employees and owners helps to indicates the level of integration in the cluster. The following table shows the profile of enterprises selected for data collection.

Table 4. 1. Selected Small and Medium enterprises from EIFCCOS

No	Name of owners	Number of employees	Product type	Level	Market destination
1	Nicolas Tenaw	56	Bags and Jacket	Medium	Local and export (Africa)
2	Kidane Hile	32	Shoes	Medium	Local and export
3	Fikadu Serko	10	Shoes	Small	Local
4	Abebe Kara	35	Ladies and kids shoe	Medium	Local
5	Mekuria Temesgen	15	Shoes	Small	Local
6	Akalu Girma	24	Belts and Bags	Small	Local
7	Lidiya Ayalew	44	Ladies and gents shoe	Medium	Local and export (Africa)
8	Sintayehu Abera	17	Military shoes	Small	Local
9	Melaku Firde	40	Civil and military shoes		Local and export (Africa)
10	Eliase Nade	31	Industrial Gloves	Medium	Local

Employee Working Culture: Educational level of all the 10 respondents (employees) is between grade 6-12 and 80% of the employees are experienced on footwear work for a long period of time up to 25 years of experience. All the respondents strongly agreed that there is no trust between them and 90% of the respondents believe that trainings and other supports from the external body contributes a lot for technology adoption and diffusion rather than working together and cooperatively with each other. The employees meet informally with their colleagues on tea and lunch break but they don’t discuss about their work. They depict cultural differences as a major barrier for less trust and cooperation. In the table below the qualitative data collected is changed in to quantitative for the ease of analysis.

Table 4. 2. Weights Given by respondents (employees) for Employee Working Culture

No	Variables	Weight (40%)	Cumulative
1	Trust between employees	0.025	0.025
2	Sharing of information through • Informal contact of employees • During working time	0.05	0.075
3	Absorptive capacity • Experience on the work • Education level	0.052	0.127
4	Individual culture (perception or attitude)	0.03332	0.16032

The cumulative result shows that the contribution of employee's culture and behavior accounts 16% of the given weight (40%) for the adoption and diffusion of technology.

Firm behavior: All the respondents were the owners from 6 medium level enterprises and 4 small enterprises who produce different leather goods. As similar to the employees, 7 of them are grade 12 completed the rest 3 have diploma and degree. From the questionnaire it is clearly understood that the function of clustering in EIFCCOS is implemented only for the purpose of raw material suppling and finished goods retailing however, sharing of knowledge and technical knowhow is totally deemed. And for the questions related to enterprises cooperation with external supporting institutions, all the owners respond that they Ranke LIDI the first and TVETS second and universities as zero level. Additionally, financial institutions are not responsibly working with them and they believe that the cooperation of all the external supporting institutions will change the existing problem.

Table 4. 3. Weights Given by Owners for Firm Behavior

No	Variables	Weight (40%)	Cumulative
1	Trust between enterprises	0.007	0.007
2	Adoption strategy • Training culture • R&D expenditure • Active participation on finance requesting	0.014	0.021
3	Willingness to cooperate • Inside the cluster • Outside the cluster	0.00875	0.02975
4	Competition in the cluster	0.035	0.06475
5	Good perception towards clustering	0.035	0.09975
6	Working culture • Social barriers	0.0175	0.11725

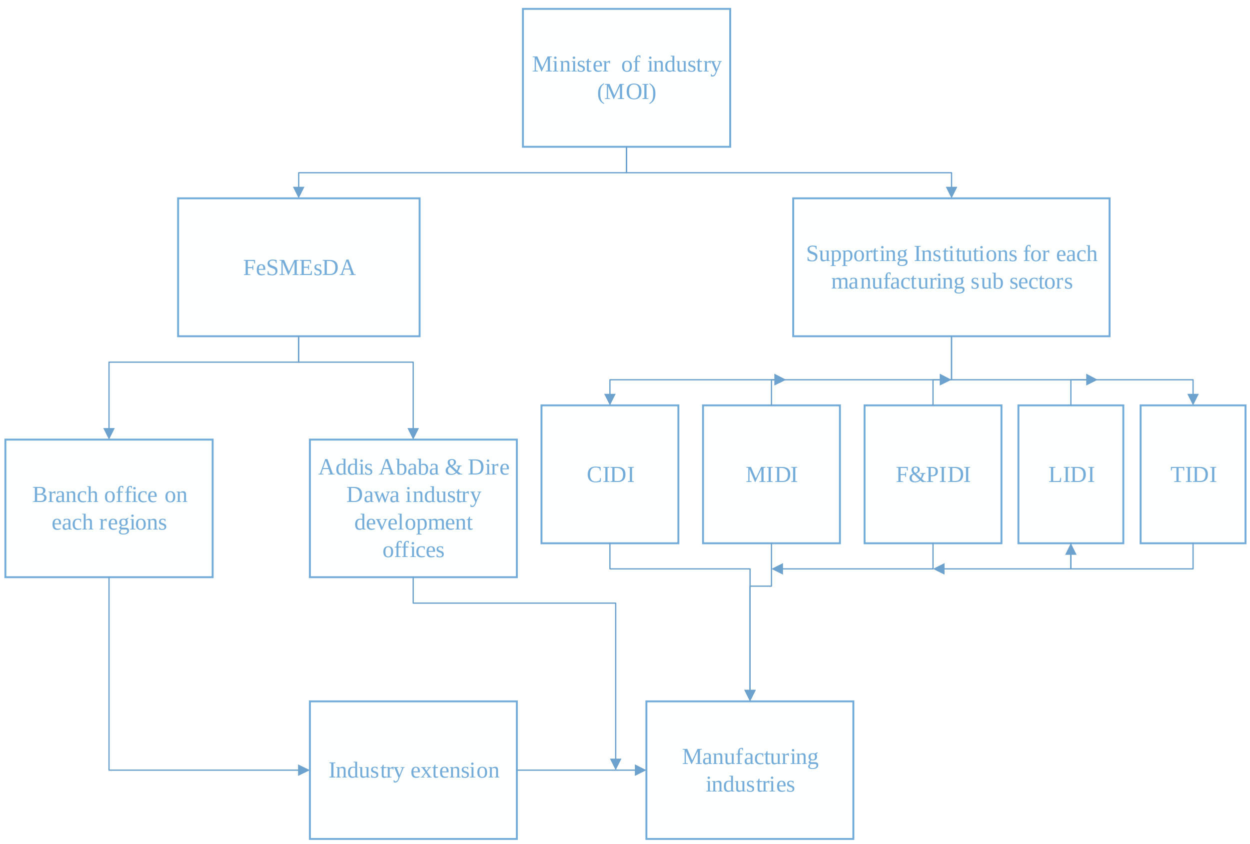
Here from the above data the contribution at enterprises level for the adoption and diffusion of technology is 12% which is at the very low level.

Technology attribute: The three main attributes of technology complexity, compatibility and relative advantage, 70% of the respondents gives more attention to adopt or not is, visible benefit or outcome gained from using it. While the complexity and compatibility of that machine or equipment is not the problem for adoption decision. From 20% given for technology attribute 9% is the interpreted value obtained from the collected data.

4.3.2 External Factors

The major external factors identified affecting technology adoption and diffusion are training, R&D and financial support. Here the overall existing collaboration system of the cluster with the providers of finance, R&D and training will be elaborated in detail. An interview was held with the supporting institutions in order to understand the existing system. Those institutions are LIDI, DBE, IEO, AAIT UIL, FeSMEsDA, AAIDB.

There are two broad classifications of organization under ministry of industry, the Federal Small and Medium Enterprises development Agency (FeSMEsDA) and five supporting institutions. These organizations are structured separately but functionally they work together with the same ultimate goal of supporting manufacturing industries. However, they have their own specific mission and objective. Under FeSMEsDA, there are Branch offices in each region, Addis Ababa and Dire Dawa this branch office will supervise and coordinate small and medium manufacturing enterprises found under each region on the other side, there are supporting institutes governed by MOI these institutions are originated for the purpose of supporting manufacturing industries. And they involve in providing different supports for the industries either directly to the firms or through different research and learning institutions.



Source: MOI, 2018

Figure 4. 4. Functional structure of industries and supporting institutions.

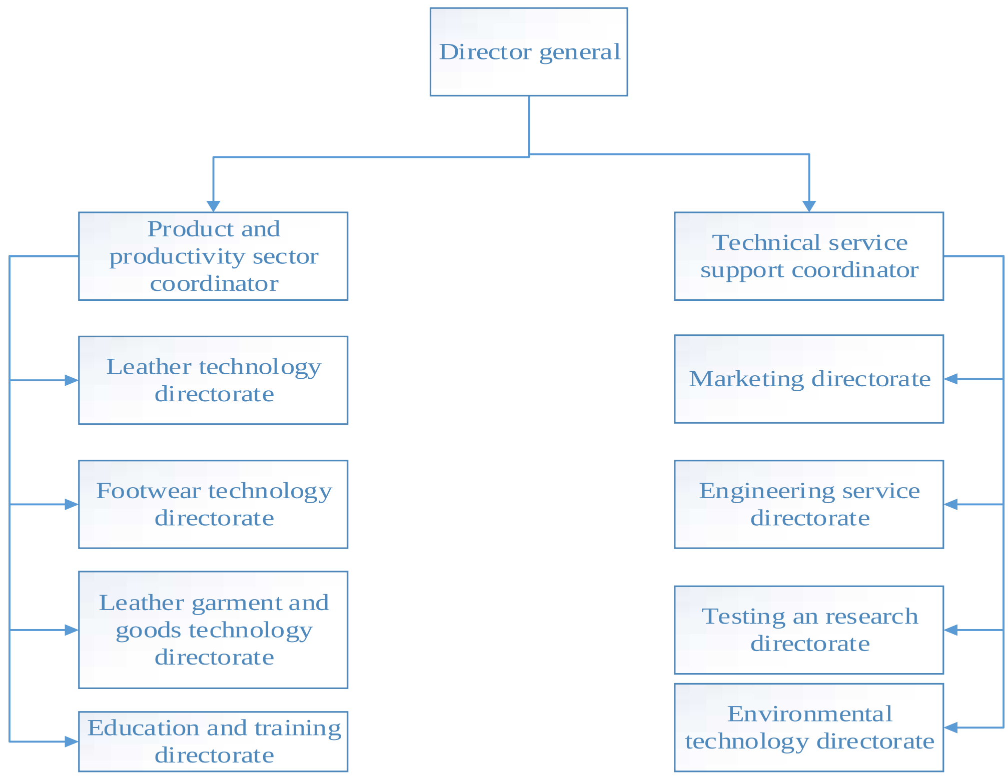
Since the government gives a special attention on developing the manufacturing sector to achieve the GTP 2 of increasing the potential of local manufacturers, for each manufacturing sectors there are supporting institutions which work in parallel to provide and facilitate them through technical trainings, research and development and other supports. Those are

- Lather industry development institute
- Textile industry development institute
- Food and pharmaceutical development institute
- Metal and engineering development institute
- Chemical industry development institute

Since the research specific case lays down on leather and leather product manufacturing enterprises, LIDI's activity is investigated through interview.

Leather Industry Development Institute (LIDI)

In an effort to turn the growth pattern and the vision of the government for the manufacturing sector into a reality, the government gives great attention and priority for the leather sector and established LIDI with the main objectives of leather sector development and competitiveness of the sector in the global arena by council of ministers' regulation No.181/2010. The main objective of LIDI is to facilitate the development and transfer of leather and leather products industries technologies, and to enable the industries become competitive and beget rapid development. In the figure below structure of the organization is shown



Source: LIDI, 2018

Figure 4. 5. LIDI's organizational structure

The institution has around 15 directorates with different functions and are structured to support the sector through each leather products like footwear, leather, lather garments and so no. It provides support both for large industries and for SMEs

Major supports: under each directorate there are teams which undertake the following tasks as a supporting skim,

Training

- long term at the engineering level and
- short term

Technical support

- Market integration
- Visibility study
- Machine maintenance
- Installation
- Product quality testing and certifying

- PDC (product development center) introduce new designs, and patterns
- Research and development

Directly or indirectly the institution is more supporting this SMEs because large industries are more or less capable of working independently. The support given for SMEs can be seen in two perspectives the one is those who produce for export market and the others are producers for local market only.

1. For local market producers: - based on their competency they will request for training then the training will be given based on their requirement the training could be given in the institute or on their factory. The other is technical support like kaizen, machine maintenance and installation, introducing new machineries and equipment this all supports are given for SMEs only if they request a support.
2. For export market producers: - the same supporting skim as the above one but here there are additional **special treatment** since they generate hard currency starting from planning together to facilitating the way incentives will be obtained from financial institutions and facilitating the way to get manufacturing sheds

Supporting schedule: there is no formal schedule for the support it is only provided if the enterprises request the institution otherwise the support will not be delivered.

Development Bank of Ethiopia (DBE)

DBE is one of governmental financing institution the bank is given the mandate to support SMEs through lease financing on the GTP two. The interview was held on the head office found around Kazan chis. Mr. Dereje (lease financing procurement and supply director) was the one who was interviewed he indicated that, so far this SMEs were the "missing middles "it is to mean that large scaled industries were supported by DBE and the micro level enterprises were supported by micro finance institutions here graduated SMEs were missed or there were no financial institutions who is responsible for this middle level industries.

Current loan processing skim: There are two ways of loan lease financing and project financing the financing policy for these two perspectives is completely different. according to the bank's policy, project financing is for large scale industries (≥ 7.5 million capital) and lease financing are for SMEs (0.5 milion-7.5 million). So, the detail explanation will be about lease financing since it is the research concern.

Lease financing is hundred present financing of capital goods (machinery and equipment) for SMEs or in other word it is capital goods supply through lease financing it implements Hire-purchase modality. From different sectors the bank supports, manufacturing is the one and from the manufacturing subsector leather goods manufacturing is the major one since the subsector gets more attention from the government.

Special Supports: The supporting system is similar both for nationally formed clusters and any other projects either large or small scale it will be based on the document that the owner come up with and due diligence assessment but there is special attention given for those who will export their product. So, SMEs who produce for export market will be given special attention either they are clustered or not.

Expected Pre- requisite from SMEs to get a lone: SMEs are expected to fulfil the following preconditions to process the lease financing

- Support the aim of structural transformation
- Support on substitution of import products by domestic products
- Source of high job opportunity
- Support the export market and source of hard currency
- Those missing middles are given high priority

Major Constraint: There are two major constraints or challenges putted for the loan getting process

1. Loan culture of the SMEs: - since they are an infant industry and were being supported at their low level, they are more concerned on an immediate cash which is readily available rather than the long-term income gained after establishing the technology or machinery.
2. Newness of the concept of lease financing: - there are many stockholders or participants during the process and this participant ate not on the same page of awareness about the system.

In the table below externa factors which affect technology adoption and diffusion their source and type is summarized from the collected data note that the interview verbatim portion are converted in to quantitative data using quantitative data coding technique.

Table 4. 4. Weight Given by Each Respondents for Each External Factors

No	Factors	Possible Sources	Weight	Cumulative weight
1	R&D (15%)	LIDI	0.025	0.025
		UIL	0.0001	0.0251
		IEO	0.026	0.0751
2	Training (15%)	LIDI	0.030	0.1051
		UIL	0.0001	0.1052
		IEO	0.035	0.1402
3	Technical support (25%)	LIDI, IE & FeSMEsDA (Machine maintenance installation and operating)	0.12	0.2602
4	Financial (30%)	DBE	0.10	0.3602
5	Regulatory (5%)	AAIDO	0.01	0.3702
		FeSMEsDA	0.005	0.3752
6	social env't (10%)	Geographical proximity	0.025	0.4002
		Social barriers	0.035	0.4352

4.4. Diffusion pattern of HDSM under EIFCCOS

There are different technologies used in leather goods production to increase the quality and aesthetic value of the product. Some of them are Thermos holding machine, splitting machine and heavy-duty stitching machine. To indicate the existing rate of technology diffusion in the cluster, adoption of Heavy Duty Stitching Machine (HDSM) is selected. The reason to select this technology is

- Adopting hard technologies (machinery and equipment) is more important for manufacturing industries to increase product’s quality standard, (Kemp & Volpi, 2008).
- Since it is combatable to study or forecast the diffusion rate, it started to be adopted (with 2 enterprises out of 280) but not yet diffused.
- Assuming that adopting this machine for the manufacturing process has visible benefit both for the firm and the customers.

The function of the machine is mainly to increase the quality of the product by adjusting the thickness of sole and adding other additional features. Here the diffusion rate of the machine inside the cluster will be forecasted using the well-known Bass Diffusion Model.

4.4.1 Application of Basic Bass Diffusion Model

There is a cluster consisting of m enterprises who will ultimately adopt let's call N(t-1) the number of enterprises who have already adopted before time t.

The model assumes that the probability that an enterprise adopts given that it has not adopted yet consists of two factors. First, there is a fixed factor p that reflects enterprises intrinsic tendency to adopt the new technology. Second, there is a factor that reflects "word of mouth" or "integration of enterprises," such that enterprises are more likely to adopt the larger the proportion of the group that has already adopted. Since that proportion is simply N(t-1) divided by m, the rate at which new enterprises adopt is p + qN(t-1)/ m, where q captures the influence of internal integration.

Since the number of enterprises who have not adopted yet before time t is m - N(t-1), and the rate at which these enterprises turn into new adopters is p + qN(t1)/ m, one can express the number of adoptions occurring at time t as:

$$N\ t\ -N\ t-1\ =\ p+qN\frac{t-1}{m}\ *\ m-N\ t-1$$

Where: m – maximum number of potential adopters

P – coefficient of innovation

Q – coefficient of imitation

N – number of enterprises adopt technology at time t

Important parameters of the model

The model has three unknown parameters, the market size m (for this research m is number of enterprises in the cluster), the coefficient of innovation p, and the coefficient of imitation q. The parameters p and q provide information about the speed of diffusion. A high value for p indicates that the diffusion has a quick start but also tapers off quickly. A high value of q indicates that the diffusion is slow at first but accelerates after a while. Of course, the number of new adoptions must start to decline at some point in time, since the number of people who have not adopted yet [m - N(t1)] becomes smaller and smaller. If the values for m, p and q is obtained, the model can also be used to forecast future adoptions using the following formula:

$$N\ t\ = m * [\exp\{-\ p + q\ t\}]/[1 + \frac{q}{p}\ \exp\{-\ p + q\ t\}]$$

Properties of the model

The model has several attractive properties which will leads one to use it,

- When q is larger than p, the cumulative number of adopters N(t) follows the type of S-curve often observed for really new product categories.
- When q is smaller than p, the cumulative number of adopters follows an inverse J-curve often observed for less risky innovations.
- Potential adopters of a technology can be divided in to two innovators and imitators.

Assumptions of the model

- Diffusion process is binary (enterprises either adopts, or waits to adopt)
- Constant maximum potential number of adopters (m)
- Eventually, all m will adopt the technology
- No repeat adoption, or replacement purchase
- The impact of word-of-mouth is independent of adoption time
- Innovation is considered independent of substitutes
- Strategies supporting the innovation are not explicitly included

- It is considered that, the value for coefficient of imitation and coefficient of innovation is estimated based on the measured values of internal factors and external factors respectively.

Estimating the parameters of the Bass Model

Bass diffusion model posits that diffusion patters can be modeled through two mechanisms, innovators adopt the technology from external source and imitators adopt the technology when getting in contact with the existing users. Crucial for the implementation of the method are the values assigned to the two parameters usually referred as p and q which mathematically described innovation and imitation mechanisms. These parameters can be obtained through two major techniques depending up on the availability of historical data.

Management Judgment:

- Potential target group Size (N).
- Number of Adoptions in the First Time Period.

Diffusion History of Analogous technology:

- Establish Similarity and Dissimilarity Relationships Between the New technology and Various Analogous technologies.
- Historical Empirical Relationship Between Innovation and Imitation Coefficients and adoption factors or attributes

In this research an integration of the two methods is used taking diffusion history of similar machines in developing countries and considering that of expert's judgment (from the measured internal and external factors).

4.4.2 Estimation of Innovation and Imitation Coefficients for HDSM in EIFCCOS

As indicated above, the expert's judgment is one of the method here implemented. Experts from all the concerned institutions who plays a major role for the adoption of technology. For the purpose of estimating innovation coefficient, all the external adoption factors are interpreted and for imitation coefficient, internal adoption factors are interpreted.

Coefficient of innovation(p): The coefficient of innovation is estimated by exploring all the external factors affecting technology adoption. Those factors identified and measured so far will be used to estimate the p value. In this case the external factors are supports from LIDI, IEO, DBE and universities this is selected because according to bass diffusion model, innovators are those who adopt the technology from the external source or by the help of external body. The innovative enterprises (who adopt from the external source) adopt HDSM through the integrated help of DBE and LIDI.

Coefficient of imitation (q): The coefficient of imitation is similarly estimated from the internal factors (inside the cluster) value. The factors are employee working culture accounts 16%, firm behavior accounts for 12% and technology attribute accounts 9%. The total is 37% obtained for internal adoption factors.

Other consideration for this value is the diffusion of similar technologies in medium scale manufacturing cluster of developing countries specific case of diffusion of manufacturing machineries in industry cluster found in Malaysia. Malaysia's case is selected because it is one of the country found under the developing world and it is the only case found for exactly the same case scenario (diffusion of hard technology inside manufacturing industry cluster). The diffusion parameters for different technologies is shown below.

Table 4. 5. Diffusion parameters of the Bass model for different manufacturing machineries in SMEs of Malaysia.

Technology	Innovation parameter (p)	Imitation parameter (q)
CO2 laser engraving machine	0.028	0.25
CNC leather cutting machine	0.005	0.84
Hydraulic plane die cutting machine	0.01	0.42
Heat transfer printing machine	0.017	0.36
Computer programmable pattern sewing	0.018	0.3

Source: Murzidah Ahmad Murad and John Douglas Thomson, 2011 suggestions of an average value of 0.03 for p and an average value of 0.37 for q.

On the p value, some modification is made to decrease from 0.03 to 0.11 (based on the result of an interpreted data regarding external factors), since external supports for all the stockholders is found to be less as compared to the internal influence.

The total number of enterprises which will eventually adopt the technology is 280 so the value of m is 280. Adoption for parameters (p=0.011, q=0.37, m=280)

Table 4. 6. Forecasted and Actual Adoption of HDSM in EIFCCOS

Year (E.C)	Quarter	Actual adoption S(t)	Cumulative actual adoption Y(t)	Forecasted current adoption S(t)	Forecasted cumulative adoption Y(t)
2010	3	2	2	3	3
	4			4	7
2011	1			5	12
	2			7	19
	3			9	28
	4			13	41
2012	1			16	57
	2			19	76
	3			23	99
	4			25	124
2013	1			27	151
	2			26	178
	3			25	203
	4			21	224
2014	1			17	241
	2			13	254
	3			9	263
	4			6	269
2015	1			4	273
	2			2	275
	3			1	276
	4			1	277
2016	1			1	278
	2			1	279

As the above table indicates, initially the adoption rate starts to increase until the threshold period. Once it reaches the threshold period number of adopters starts to decline as shown on the graph below. The coefficient parameters are verified based on an error values of actual and forecasted. The current actual adoption is 2, and the forecasted current adoption is 2.443 (approximated to 3, since 2.443 enterprise is undefined).

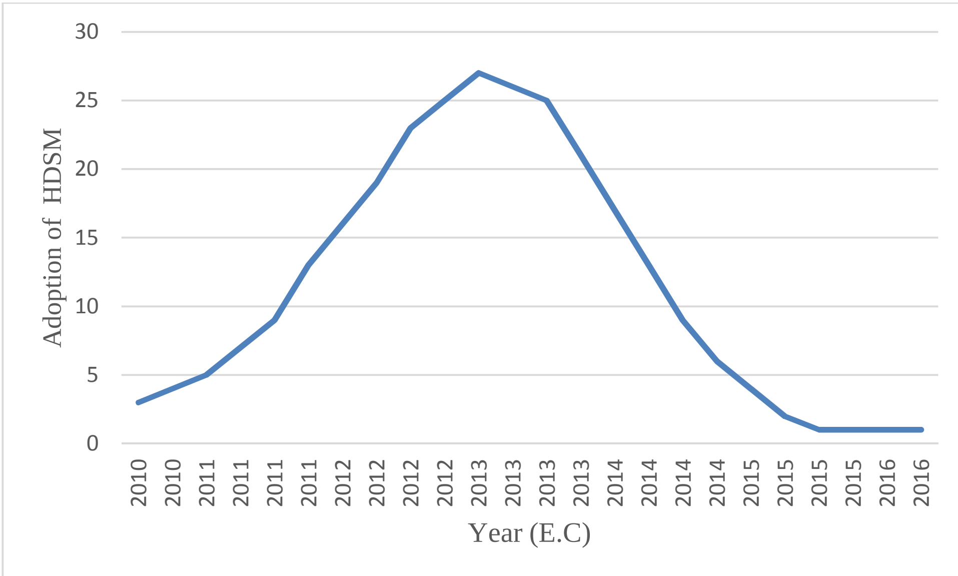


Figure 4. 6. Forecasted current adoption of HDSM in EIFCCOS

The result of the analysis indicates the possible time or year expected for the diffusion of HDSM inside EIFCCOS. It takes the next 6years (from half of 2010-2016 E.C) to be diffused. As Frank M. Bass categorizes, the first two enterprises are innovators for that specific target group (EIFCCOS) and the rest 278 are imitators. If necessary, those imitators can be classified as early adopters, early majority, late majority and laggards as Based on the fraction weight Rogers putted. It is also possible to calculate number of pick adoption

$$S(T*) = \frac{m(p+q)^2}{4q}$$

Similarly, the threshold time or the time of pick adoption can be calculated using the following formula

$$T* = \frac{\ln(\frac{q}{p})}{p+q}$$

Using the above Basses formulas, the maximum number of enterprises which will adopt HDSM is 27 it is the same result from the forecasted value (on the first quarter 2013) or at the 11th period. The cumulative adoption is shown below which follows normal diffusion curve or S-curve.

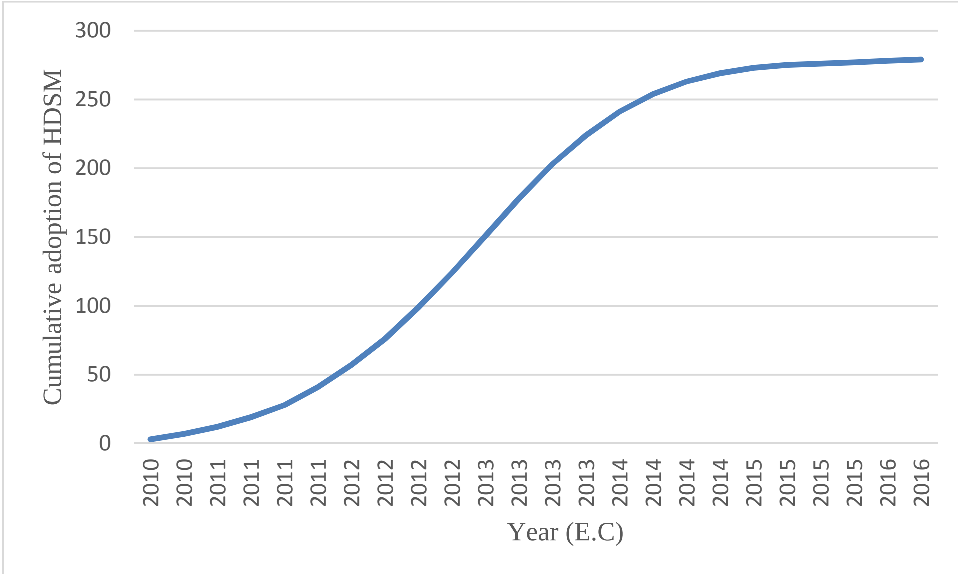


Figure 4. 7. Forecasted cumulative adoption of HDSM in EIFCCOS

From the above analysis it is understood that the concept of clustering for the accelerated technology diffusion is not as it is expected to be. Major expectations from clustering of these manufacturing enterprises to integrate their development through sharing of technologies. However, in EIFCCOS, there is weak interaction both internally and externally. Because of this the diffusion rate of the sample taken machine is very slow taking in to account the benefit gained from clustering. Currently its two enterprises using that machine and to be diffused in the cluster it almost takes six years which is a long time not for other scenario but for these geographically close enterprises. The possible reason for this is the lack of integration and cooperation endogenously and exogenously. In the next perspective section an important internal and external factors are prioritized using AHP.

4.5. Analytical Hierarchy Process to Prioritize Influencing factors

An internal and external factors extracted from the literature needs to be prioritized based on their importance to identify the most influencing factors for technology adoption and diffusion both from an internal and external perspective. Since the critical few factors are crucial than the many. Analytical hierarchy process is one of the well-known approach in which it can indicate the rank or priority of each input factors among each other through pair wise comparison.

The reason to identify the critical factors is to define major actors or agents for the model based on the factors. Directly or indirectly these factors play a great role for firms' technology adoption and diffusion as a result the factors will be an entity for the agent based technology diffusion model.

4.5.1. Internal Factors Analysis

Internal factors identified are directly linked to the level of interaction between industries inside the cluster both at the employee and firm level. Below on the AHP analysis the factors are prioritized based on their importance for the diffusion of technology.

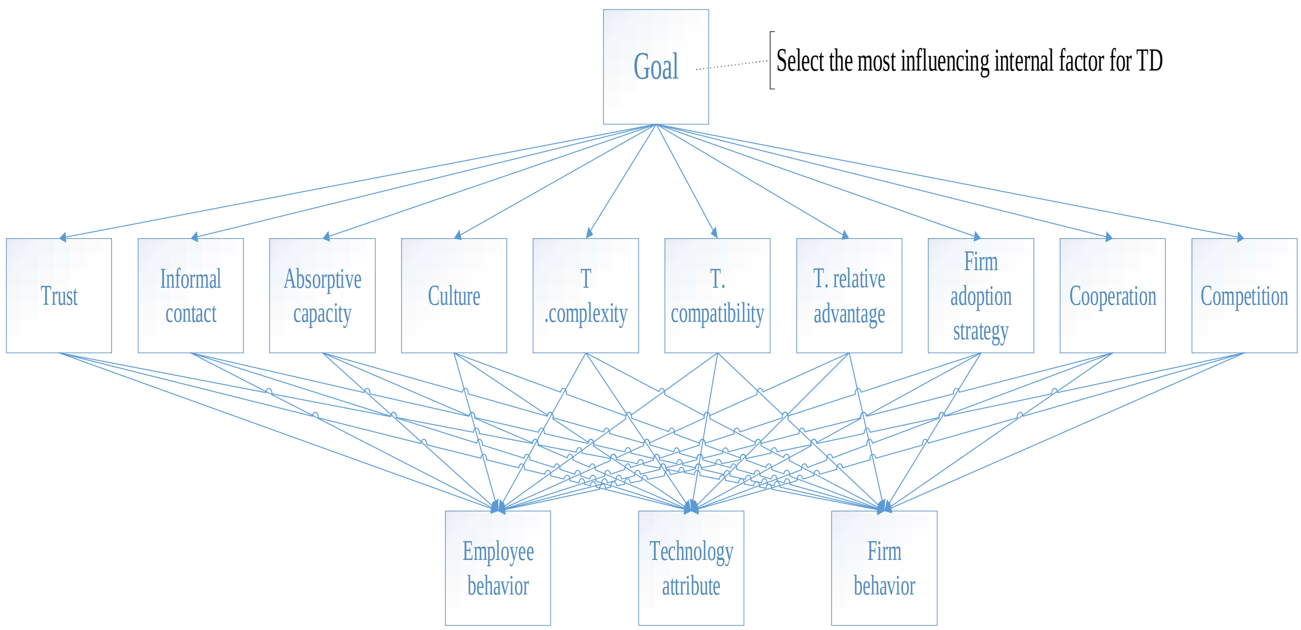


Figure 4. 8. Hierarchal structure of internal factors

The data obtained from the Saaty's scale pairwise comparison of importance is directly taken form the questionnaire. The elements in each level were compared with each other using the values as per Saaty's scale and synthesis of the pair-wise comparisons is done. For each criterion (employee behavior, technology attribute and firm behavior), pair-wise comparisons are made for alternatives with each sub factors. Pairwise comparison and priority vectors are calculated for each alternative with respect to all criterions as follows

Table 4. 7. Pair wise comparison matrix of sub criterions with respect to employee behavior

Employee behavior	Trust	Informal contact	Absorptive capacity	Culture
Trust	1	3	1/7	1
Informal contact	1/3	1	1/9	1/3
Absorptive capacity	7	9	1	7
Culture	1	3	1/7	1

Table 4. 8. Priority Vector for sub criterions with Respect to employee behavior (Inconsistency = 0.052)

Employee behavior	Trust	Informal contact	Absorptive capacity	Culture	Priority vector
Trust	0.107	0.187	0.102	0.107	0.125
Informal contact	0.036	0.062	0.079	0.036	0.053
Absorptive capacity	0.75	0.562	0.714	0.75	0.7
Culture	0.107	0.187	0.102	0.107	0.125

The priority vector shows the relative weights among the factors that are compared as shown, the most dominant factor with respect to employee behavior is absorptive capacity with the weight of 70%, trust and culture equally 12.5% and informal contact 5.3%.

The same pair wise comparison matrix of sub criterions is done with respect to the second criterions or alternatives which is technology attribute.

Table 4. 9. Pair wise comparison matrix of sub criterions with respect technology attribute

Technology attribute	Complexity	Compatibility	Relative advantage
Complexity	1	½	1/7
Compatibility	2	1	1/5
Relative advantage	7	5	1

Table 4. 10. Priority Vector for sub criterions with Respect to technology attribute (Inconsistency = 0.059)

Technology attribute	Complexity	Compatibility	Relative advantage	Priority vector
Complexity	0.1	0.077	0.106	0.094
Compatibility	0.2	0.153	0.149	0.167
Relative advantage	0.7	0.77	0.745	0.74

The result indicates that for the pair wise comparison with respect to technology attribute is 74%, 16.7% and 9.4% for relative advantage, compatibility and complexity respectively.

The last pair wise comparison matrix of sub criterions is done with respect to the last factor which is firm behavior.

Table 4. 11. Pair wise comparison matrix of sub criterions with respect to firm behavior

Firm behavior	Adoption strategy	Cooperation	Competition	Trust	Culture
Adoption strategy	1	3	2	2	2
Cooperation	1/3	1	2	1	2
Competition	½	½	1	1	2
Trust	½	1	1	1	2
Culture	½	½	½	1/2	1

Table 4. 12. Priority Vector for sub criterions with Respect to firm behavior (Inconsistency = 0.07)

Firm behavior	Adoption strategy	Cooperation	Competition	Trust	Culture	Priority vector
Adoption strategy	0.353	0.5	0.31	0.363	0.22	0.349
Cooperation	0.117	0.16	0.31	0.181	0.22	0.197
Competition	0.176	0.08	0.15	0.181	0.22	0.161
Trust	0.176	0.16	0.15	0.181	0.22	0.1774
Culture	0.176	0.08	0.076	0.090	0.11	0.1064

The result is 35%, 19.7%, 16%, 17.7% and 10.6% for firm adoption strategy, cooperation, competition, trust and culture respectively.

From the above analysis the prioritized factors for adoption and diffusion of technology are identified as

- Employees' absorptive capacity
- Technologies' relative advantage
- Firms' adoption strategy

4.5.2. External Factors Analysis

The method is implemented similarly for the external factors. It starts with drawing the hierarchical structure.

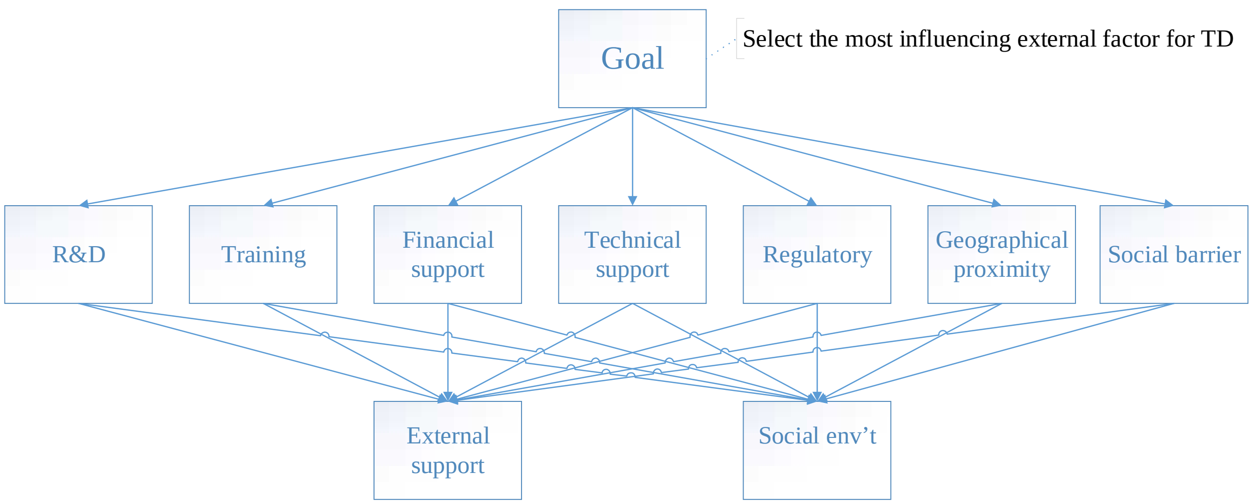


Figure 4. 9. Hierarchal structure of external factors

Table 4. 13. Pair wise comparison matrix of sub criterions with respect to external supports

External support	R&D	Training	Financial	Technical	Regulatory
R&D	1	½	1/5	1	5
Training	2	1	1/3	½	5
Financial	5	3	1	1	9
Technical	1	2	1	1	7
Regulatory	1/5	1/5	1/9	1/7	1

Table 4. 14. Priority Vector for sub criterions with Respect to external support (Inconsistency = 0.064)

External support	R&D	Training	Financial	Technical	Regulatory	Priority vector
R&D	0.1	0.074	0.075	0.274	0.185	0.141
Training	0.21	0.149	0.126	0.137	0.185	0.170
Financial	0.54	0.447	0.378	0.274	0.33	0.393
Technical	0.1	0.298	0.378	0.274	0.259	0.261
Regulatory	0.021	0.029	0.042	0.039	0.037	0.033

From the computation result 39.3%, 26%, 17%, 14% and 3.3% for financial support, technical support, trainings, R&D and regulatory actions respectively. The same matrix analysis is done for the remaining decision factor which is sub criterions with respect to social environment

Table 4. 15. Pair wise comparison matrix of sub criterions with respect to social environment

Social environment	Geographical proximity	Social barriers
Geographical proximity	1	5
Social barriers	1/5	1

Table 4. 16. Priority Vector for sub criterions with Respect to external support (Inconsistency = 0.064)

Social environment	Geographical proximity	Social barriers	Priority vector
Geographical proximity	0.833	0.833	0.833
Social barriers	0.166	0.166	0.166

The priority vector result obtained indicates the priority 83.8% for geographical proximity and 16.6% for social barriers. Therefor the most influencing external factors for adoption and diffusion of technology are

- Financial support and
- Technical support

Finally, from AHP analysis an influencing factor both from external and internal perspective is identified as a result, employees' absorptive capacity, relative advantage of technology and firm adoption strategy are high priority internal factors. Similarly, financial support and technical supports are high priority external factors.

Chapter Five

Technology Diffusion Model Development and Validation

In this section Agent based model of technology diffusion is developed. The primary objective in developing an ABM for this study is to demonstrate the feasibility and advantages of using such a platform to understand the effect of interaction that occurs between SMEs industrial cluster and with the outside environment for adoption and diffusion of technology. The diffusion model is distinct since such technologies adopted in industrial cluster are once or infrequently.

The agents in this ABM resides in a random network with a structure allowing interactions among enterprises in the cluster and with external supporting organizations. For the purpose of this research, adoption decision corresponds to the fuzzy set. The individual enterprise adoption decision yields the diffusion curve and this model allows study of technology diffusion at micro (adoption) and macro (diffusion) levels.

The modeling sequence starts with constructing conceptual model comprises of three major parts, defined agents, communication network structure and adoption decision tree. Agents are defined with the domain of critical factors identified from AHP and agent's adoption decision considers fuzzy logic analysis. The reason behind implementing fuzziness is, to put agent's technology adoption decision under uncertainty. Finally, model is validated through simulation experiment.

Assumptions for the model entities:

- Innovative enterprises in the cluster need a triggering support from external body for extracting new technology (usually rely on co-operation with external source).
- Both imitative and innovative enterprise agents are considered as freely moving and dynamic agents (an enterprise is represented by "owner")
- An increased number of innovator enterprise agents results from an active participation of supporting agents
- Technical supporting agents are considered as either the source of technology or a channel to transfer from its source to an enterprise

5.1. Conceptual Features of the Agent Based Model

The conceptual features of this model comprise of three main components which intern will be described in detail.

1. Defining agents
2. Agents' interaction topology
3. Agents' adoption decision

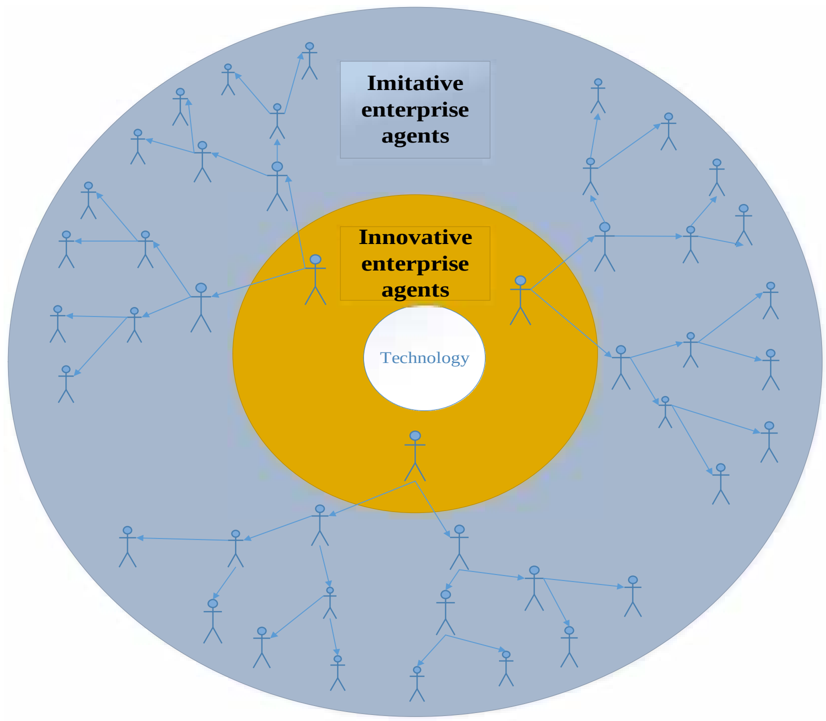
5.1.1 Defining Agents

The decision-making discrete entity with its own diverse and heterogeneous behavior in an agent-based model is called an agent. With ABM, Interaction between agents and individual agent decisions are explicitly modeled. As adoption decisions regarding manufacturing technologies are usually made at the enterprise level, an enterprise is the crucial decision-making entity within the diffusion model presented here. In the model, however, an agent within the diffusion model doesn't represent one specific enterprise but symbolizes all enterprises of one cluster. The major agents identified for this model are therefore supporting agents, enterprise agents and regulatory agents.

Enterprise agents: Enterprise agents are modeled to make adoption decisions in which by considering heterogeneity of enterprises (from Probit model) based on their heterogony, these enterprise agents are classified as innovator and imitator. The adoption decision for innovator enterprises agents is made because of the interaction with supporting agents and for imitator enterprise agents, the decision is made because of the interaction with innovative enterprise agents in the cluster.

- ***Innovator enterprise agents***: Are those who want to explore new technologies or influential enterprises in the cluster and active seekers of technologies from the external source. They have relationships with other enterprises in their network, and with suppliers of technology. These enterprises adopt technology through triggering support from different external source here, innovative enterprise agents get primary support.
- ***Imitator enterprise agents***: In this model imitator enterprises are considered as those who are not active on seeking new technology by themselves as a result these enterprises can be competitive by adopting technologies from the innovator enterprises and

additionally they will get secondary support from supporting gents. The overall technology diffusion process is as shown below on the figure.



Source: Modified from Balakrishnan, 2007

Figure 5. 1. Technology diffusion through innovative and imitative enterprise agents for industrial clusters

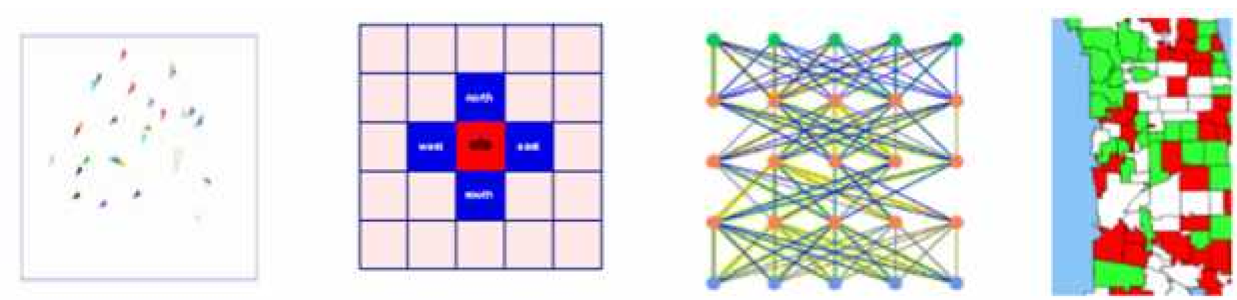
Supporting agents: from the analytical hierarchy process result, the prior supporting entities are financial and technical support as a result, these two factors are included in the model.

- ***Technical support agents:*** Technical supports are mainly visibility study, machine maintenance, installation, Product quality testing and certifying, PDC (product development) introduce new designs and patterns and Research and development these technical supports are provided mainly through leather industry development institute (LIDI) and taken as technical support agent.
- ***Financial support agents***: The mandate to provide financial support for small and medium enterprises is given for DBE as a result, DBE is taken as financial support agent.

Regulatory agents: Since all SMEs in Addis Ababa city are governed under Addis Ababa Industry Development office, it is considered as regulatory agent. AAIDO is selected because all the coordination and control actions are undertaken by the office. The regulatory agent establishes policies in order to influence both supporting institutions and the enterprise.

5.1.2 Agent's Interaction Topology

There are different types of interaction topologies in ABM the first one is Euclidean here agents can move in free (continuous) space the second one is von Neumann neighborhood, agents interacting in local "neighborhoods" the third one is Network, agents are connected by networks of various types the last one is geographic information system here agents can move over geographical information systems.



Euclidean Grid: von Neumann Network GIS:
Geographic

Neighborhood Information
System

Source: Center for Complex Adaptive Agent Systems Simulation by Macal and North, 2006

Figure 5. 2. Agents' Interaction Topologies

Among the above agents' interaction topologies, Euclidean" is selected since it allows random and free movement of agents on their grid.

5.1.2.1 Communication Network for the Selected Topology

Two basic communication networks availed, technology exchange (technology passed from one enterprise to another in the cluster) and technology exploitation (technology transferred to an enterprise from an external source). Technology transfer networks enable enterprises to reach a common understanding regarding technologies quickly. Important aspects of enterprises technology transfer networks are the type and size of the network. Here the network size will not be an issue since the model is developed for clustered enterprises usually small networks are more efficient since communications are easy. The type of network selected is “random” this type of network adapts to changing internal and external factors and evolve from one agent to another in which the agents are randomly moving agents.

Communication channels and network structure implemented in this model aims at enhancing the diffusion of technology as the influence of external support agents on innovative enterprises, there will be adoption decision as a result of these innovative enterprises adoption decision, those imitative enterprise agents get an opportunity to have knowhow about the technology and become motivated to adopt as well. Therefor the network structure is an active process whereby technology is carried across the border of three major entities the first is from an external source to an innovative enterprise agent the other is form innovative enterprise agents to imitative enterprise agent and technology transfer channels are the link between entities. The dynamic nature of the network for interaction between agents is expressed as;

S: *the supporting agents*

S(t) *= (the number of agents at a discrete time t that can give support for innovative enterprise agents from the source)*

In: *innovative enterprise agents*

In(t) *= (the number of agents at a discrete time who adopt technology and can transfer for imitative enterprise agents)*

Im: *imitative enterprise agents*

Im(t) *= (the number of agents at a discrete time who adopt technology from innovative enterprise agents)*

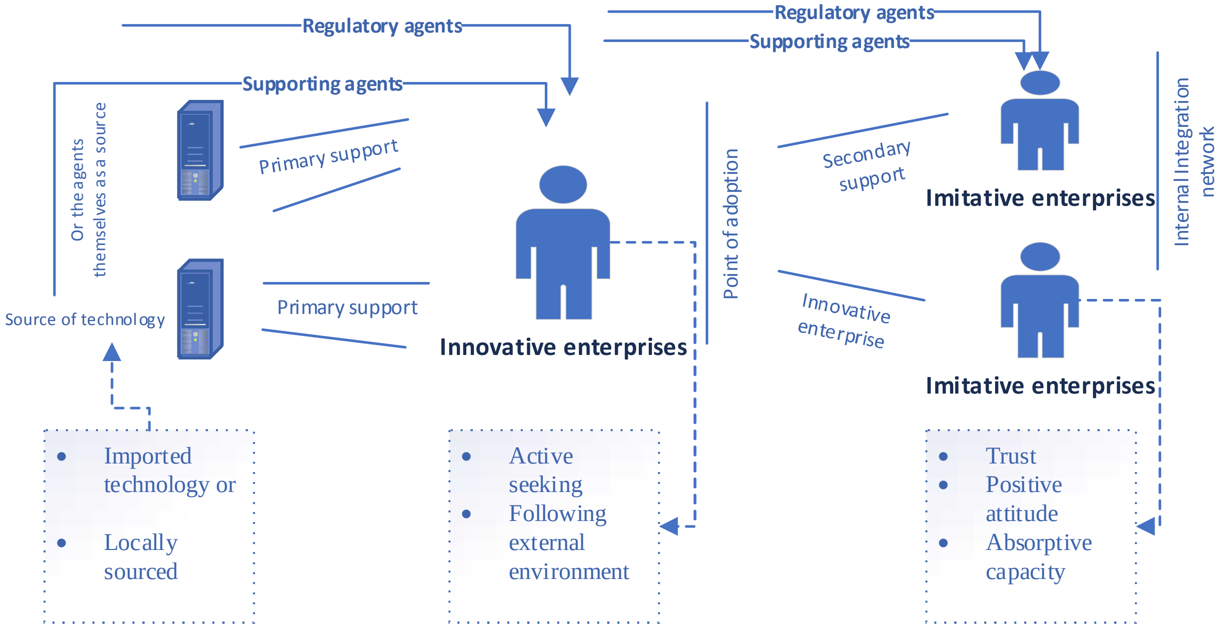


Figure 5. 3. Agent's Communication network design

The function of supporting agents is divided in two phases as primary and secondary supporting phase. Here the role of supporting agents will be different for each phase on the phase of primary support, it is a triggering support for innovative enterprise agents for the purpose of adoption of new technology. On the other hand, the secondary phase support is provided for those imitative enterprise agents to adopt technology in which those innovative enterprises already adopt.

5.1.3 Agent's Adoption Decision

Adoption decision factor considered for the purpose of this model are the above prioritized internal and external factors. Before reaching at the point either adopt the technology or not, the decision will be under a consideration of fuzzy set rules that means, an enterprise is considered as it adopts the technology if the rules get true value. As a result, fuzzification is required for the adoption decision.

Fuzzy Logic for Enterprises Technology Adoption Decision

Fuzzy concepts first introduced by A. Zadeh in the 1960s and 70s. Traditional or binary computational logic and set theory is all about true or false, zero or one, in or out, black or white (no grey) not the case with fuzzy logic and fuzzy sets. Similarly, for this research there is an adoption decision for the enterprises in which they may or may not adopt technology. It is difficult to make the decision process simply as either they adopt or not adopt, rather some degree of membership between the two binary terms have to be considered.

Development of the fuzzy set

Fuzzy set can be constructed by converting a crisp set of input data gathered into a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. The first step in the development of a fuzzy set is creating a comprehensive list of evaluation criteria or fuzzy rules. In this case the evaluation criterions are linguistic variables used in describing prioritized factors for technology adoption decision as shown in the table below.

Table 5. 1. Linguistic membership and its likelihood

Rating	Linguistic M.	Likelihood of enterprise technology adoption decision
1	Rarely	If the enterprise has knowhow about the importance of the technology and not willing to adopt and probably never will adopt.
2	Unlikely	If the enterprise doesn't have knowhow about the importance of the technology and there is a possibility either to be willing to adopt or not, once it gets information
3	Possibly	If the enterprise already has the technology but of different reasons it is not operating or not being used
4	Likely	If the technology is in the process of procurement (embodied) or knowledge building (disembodied).
5	Certainly	If the enterprises accept the importance of adopting the technology and is already installed and operating

Estimation of membership function

Membership functions are used to represent linguistic states of a variable. Each element on the relevant scale of a variable is assigned a membership value ranging from 0 (no membership) to 1 (full membership) in each membership function, indicating its degree of belongingness to the membership function used to represent the linguistic term. Membership values can be calculated using the following formula.

$$A\ x_i = \frac{P_{xi}}{N}$$

I. Innovators' adoption decision

The first step is to obtain the membership value of each external factor (since innovators adopt technology from external sources) these are Technical support and Financial support. For the first factor 6 respondents from LIDI and 6 enterprises owners from EIFCCOS were asked and gave their response.

(S1) = Technical support

Table 5. 2. Membership values for S1

Scale	1	2	3	4	5
(Ps1)	0	0	4	3	2
A(S1)	0.00	0	0.33	0.25	0.17

In order to express the membership values in fuzzy set between 0 and 1 each value in the above table are normalized using Max-Min principle

$$A\ RN = \frac{A\ S}{MAX.VALUE}$$

Table 5. 3. Normalized membership values for S1

A(S1)	0.00	0.00	0.33	0.25	0.17
A(SN)	0	0	1	0.75	0.5

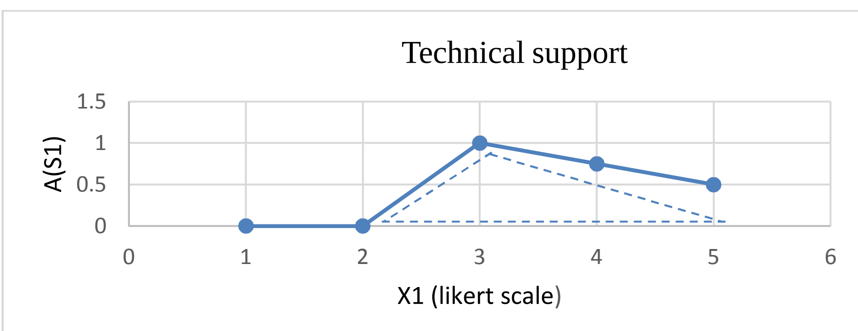


Figure 5. 4. Best Fit Triangular Membership Function for Technical Support

(S2) = Financial support

Table 5. 4. Membership values for S2

Scale	1	2	3	4	5
(Ps2)	0	0	0	6	4
A(S2)	0.00	0.00	0.00	0.5	0.33

Table 5. 5. Normalized membership values for S2

A(S2)	0.00	0.00	0.00	0.5	0.33
A(SN)	0	0	0	1	0.67

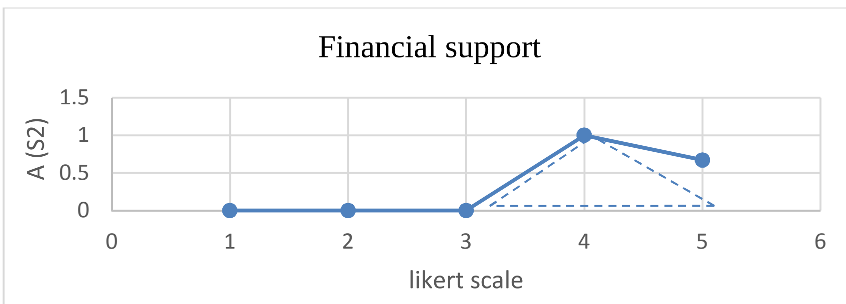


Figure 5. 5. Best Fit Triangular Membership Function for Financial Support

The magnitude of the two adoption decision factors for innovator enterprises S1 (a=2, m=3, b=5) and S2 (c=3, n= 4, d=5). Multiplying the two fuzzy sets S1*S2 equals (5, 12, 25). Using the following formula, it is possible to compute their α-cut.

S1α = [(m-a) α +a, (m-b) α+b]

S2α = [(n-c) α + c, (n-d) α +d]

For the left side, 5 ≤ Z1 ≤ 12, the result obtained is $\boldsymbol{\alpha^2+5\alpha+6=0}$ and for the right side, 12 ≤ Z2 ≤ 25, $\boldsymbol{2\alpha^2-15\alpha+25=0}$

Therefor adoption decision magnitude *M(Z)* becomes,

$$M\ z\ = -\begin{matrix} 5+\frac{\sqrt{2}}{2} \\ 0 \\ 5-\frac{\sqrt{1}}{2} \end{matrix}, \text{ other wise}$$

α - cut method to get decision magnitude

In this method, the α value commonly used is 85% confidence interval or 0.85, from statistical analysis. Using this value, the decision magnitude becomes, M= [Z1, Z2] = [α^2+5 α+6, 2α^2-15α+25] = [9.0706, 13.695] which is equivalent with [2.26, 3.4].

II. Imitators' adoption decision

The same analysis is done for imitators' adoption decision using high prioritized internal factors (Employees' absorptive capacity and Technologies' relative advantage). Here, only the result is presented

S1 = Absorptive capacity

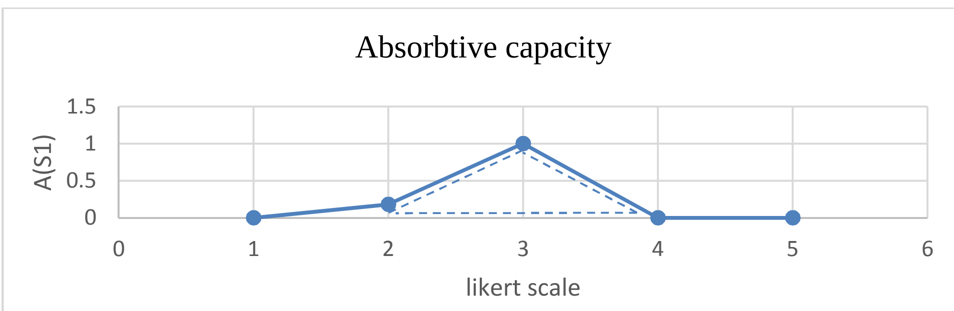


Figure 5. 6. Best fit triangular membership function for employees' absorptive capacity

S2 = Technologies' relative advantage

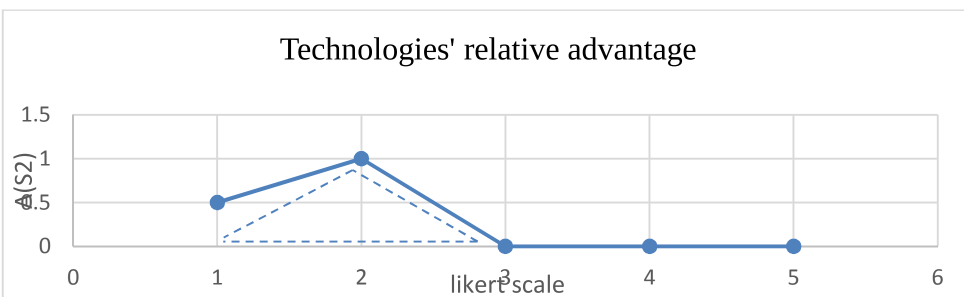


Figure 5. 7. Best Fit triangular membership function for technologies' relative advantages

The magnitude of the two adoption decision factors for innovator enterprises S1 (a=2, m=3, b=4) and S2 (c=1, n= 2, d=3). Multiplying the two fuzzy sets S1*S2 equals (2, 6, 12). For the left side, $2 \leq Z1 \leq 6$, the result is $\boldsymbol{-\alpha^2+3\alpha+2=0}$ and for the right side, $6 \leq Z2 \leq 12$, the result is $\boldsymbol{\alpha^2-7\alpha+12=0}$
Therefor adoption decision magnitude *M(Z)* becomes,

$$M\ z \ = \ \begin{matrix} 3+\frac{\sqrt{17}}{2} \\ 0 \\ 7-\frac{\sqrt{1}}{2} \end{matrix}$$

Similar to the above, using α - cut method, the decision magnitude becomes, M= [Z1, Z2] = [-α2+3α+2, α2-7α+12] = [5.27, 6.77] which is equivalent with [2.63, 3.9].

Based on the above analysis, it is possible to put an enterprises technology adoption decision under fuzzy state. The general frame work for enterprises adoption decision is shown below.

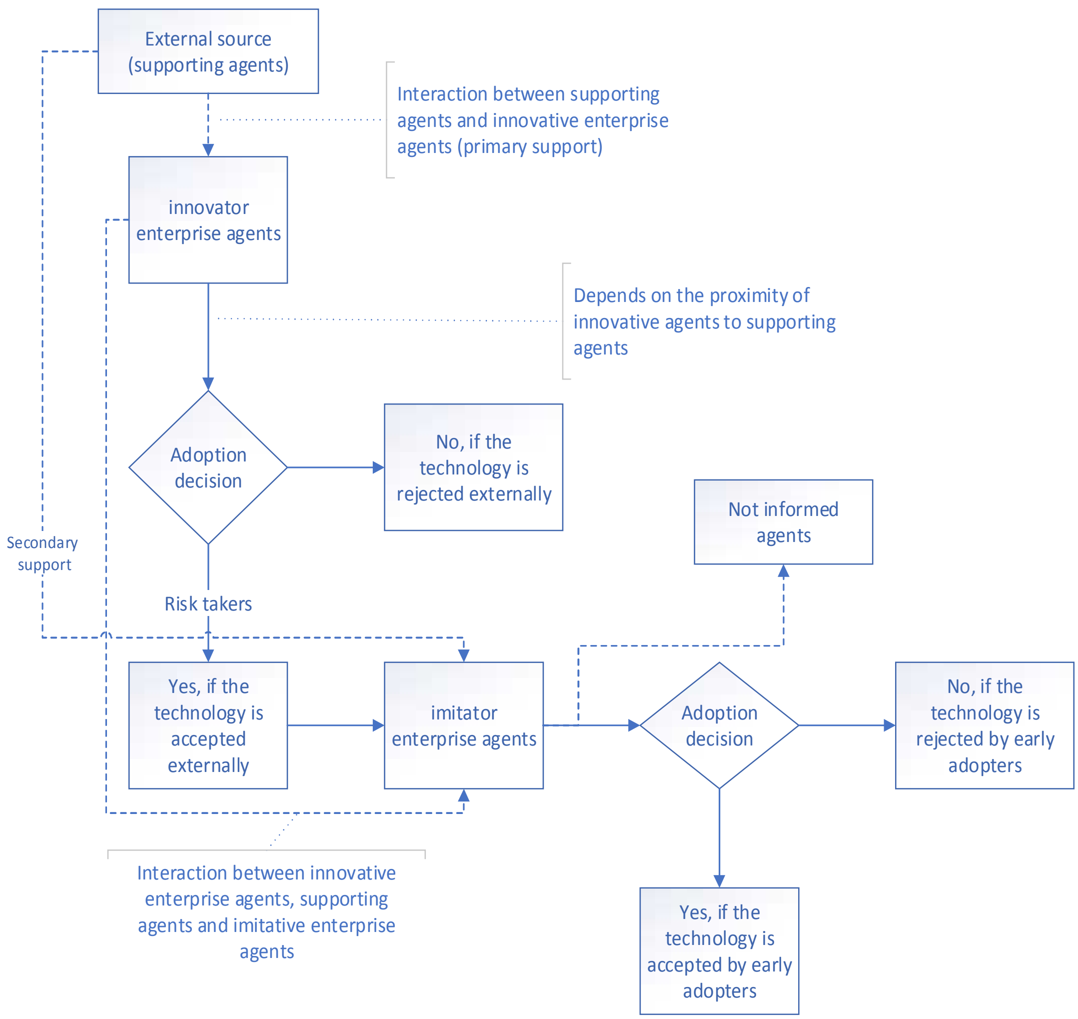


Figure 5. 8. Agent's Technology adoption decision

5.2. Model Validation

The above model is validated using simulation technique. The simulation model is done on NETLOGO (6.0.2) version which is used to simulate agent-based model environment. NETLOGO coding system is introduced by Uri Wilensky (1999). Before Wilensky, the coding was based on a programming language called "logo" by Seymour Papert (1968) from MIT. Net logo is a discrete time simulation it is to mean that there are patches (the world) and turtles (agents), both the agents and world performs in a discretized time called ticks. Generally, it simulates the interaction of agents in their world of grid.

Function of the simulation model

This model simulates the diffusion of technology adoption through interaction of a randomly moving heterogeneous enterprise agents.

The model working environment

The agents wander randomly throughout the simulation grid. the turtles or agents taken for the purpose of the simulation are enterprise agents the reason for taking only this enterprise agent is, the basic concept of ABM (the agents directly interact on their world as a result, there will be a defined state of change) so there should be direct involvement of agents. Enterprise agents in the simulation grid are classified as,

- Innovators
- Imitators
- Informed (those who get knowhow)
- Nonadopters (those who decide to don't adopt)
- Adopters (those who decide to adopt)

5.2.1 Simulating Diffusion of HDSM in EIFCCOS (Existing Situation)

As stated above NETLOGO 6.0.2 is used to simulate the model. The grid or world found on the interface of NETLOGO is taken as one cluster (EIFCCOS). Under EIFCCOS currently there are 280 enterprises among those 2 of them adopt HDSM and the rest 278 don't adopt yet. By adjusting the sliders to fit to the existing situation, the simulation is undertaken. Initially there are two types of enterprises in the cluster, innovator and imitator. Innovators are those who adopt HDSM and imitators are the rest who don't adopt yet.

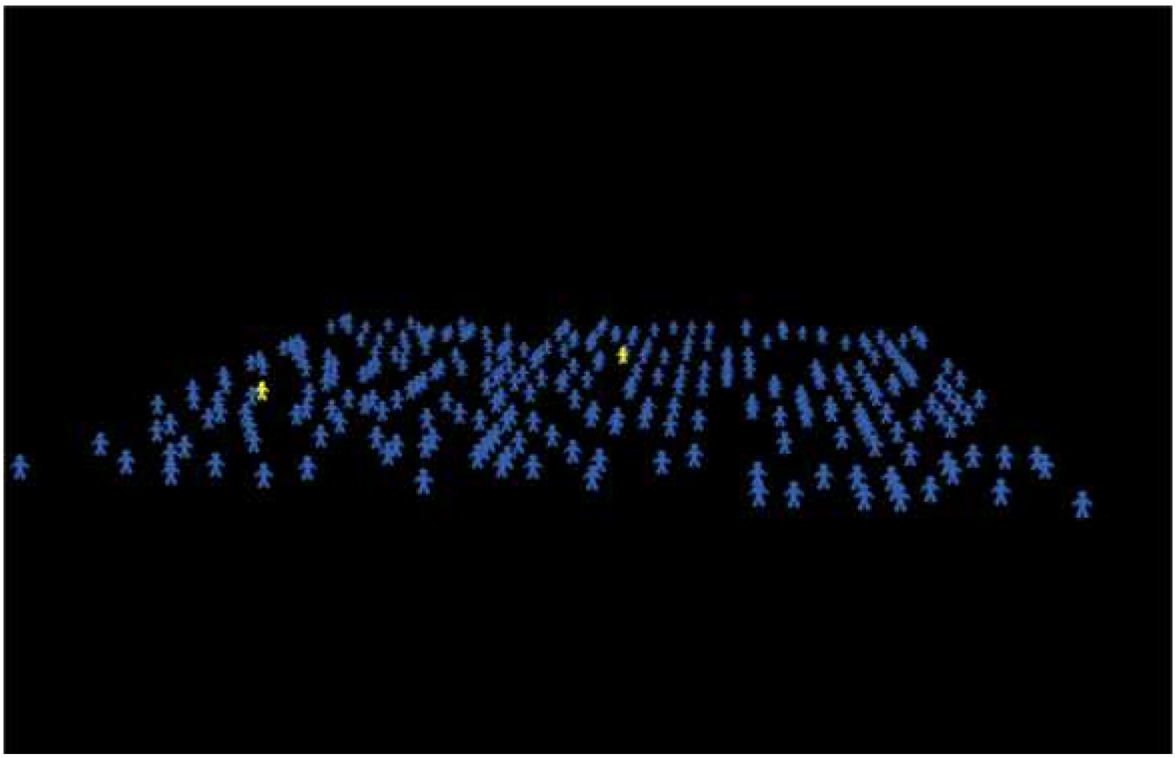


Figure 5. 9. 3D view of Initial imitator and innovator agents on the simulation grid (EIFCCOS)

The "yellow" one is to indicate innovator agents and the "blue" one for imitator agents. If imitative agent occupies a patch or a grid (cluster) with innovator agent, an imitator agent has a chance to adopt or not adopt a technology.

The yellow agents interact with the blue agents and a state of change happened which is the blue agents become informed or get knowhow about the technology during this time, there will be a probability of being willing to adopt or not. Those who are willing to adopt become "pink" stays as pink until the end of processing period (the time to process HDSM from procurement up to installation). The rest who are not willing to adopt become “green”.

This is controlled by the adoption-chance slider and nonadoption-chance slider. An imitator agent that does not become informed, becomes non-adopter (note: there is a different between not willing and not informed). An agent stays informed (get knowhow) for a period determined by the processing-period slider during this time, the agent is on the process to fully or certainly adopt.

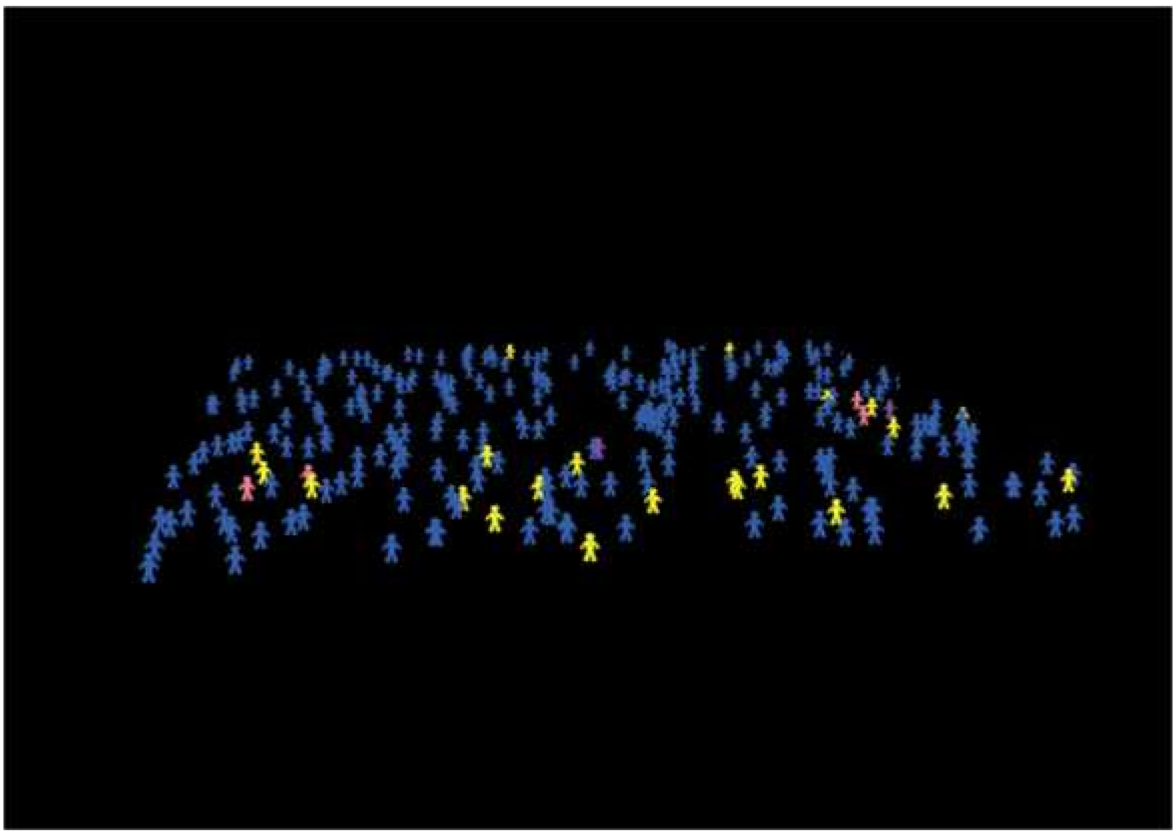


Figure 5. 10. During agents’ state of change or the diffusion process

This process will continue until the threshold period and those who know the technology are considered as innovative for the non-adopters. At the end of the simulation the agents remain on the grid are adopters as “purple”, not informed (who don’t get informed) stayed on their original state as “blue” and not willing agents (who get informed) as “green” nonadopter agents.

At this stage the simulation will end up and there will not be any state of change happened even if the interaction between agents is continued. This is controlled by technology-period slider it controls the threshold period of the technology.

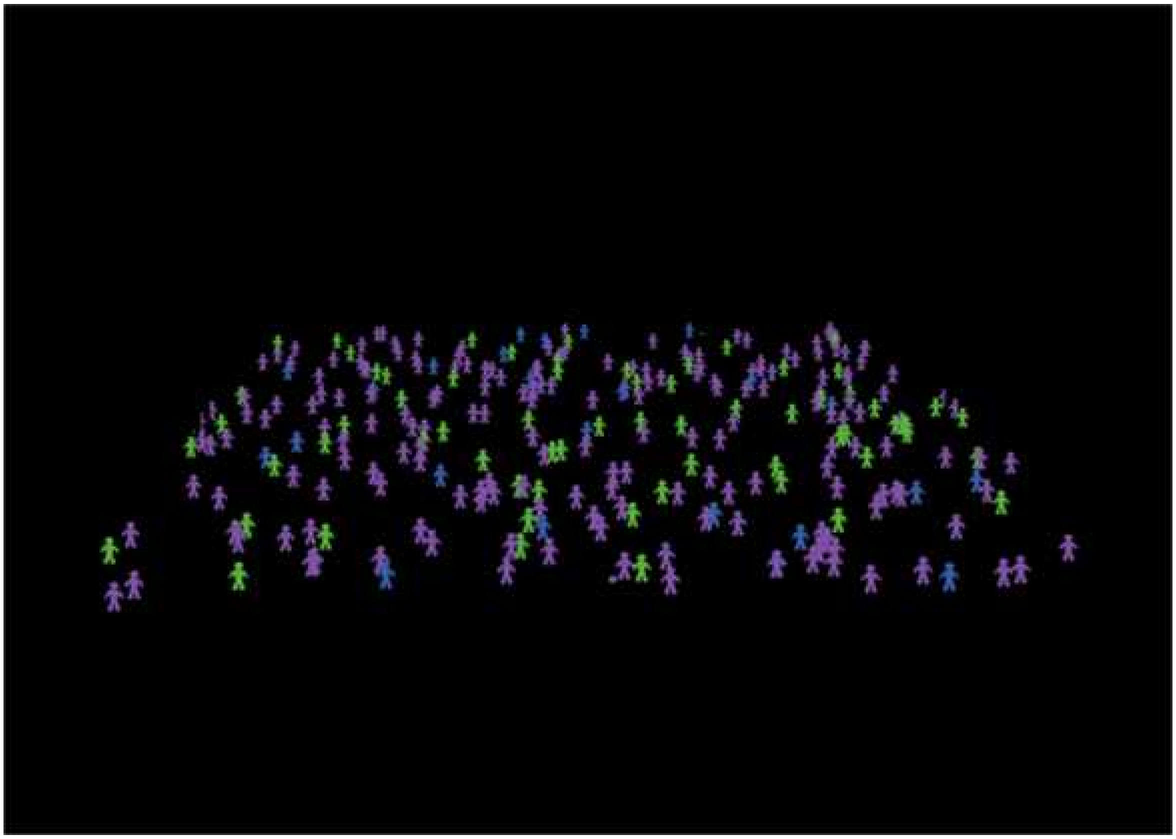
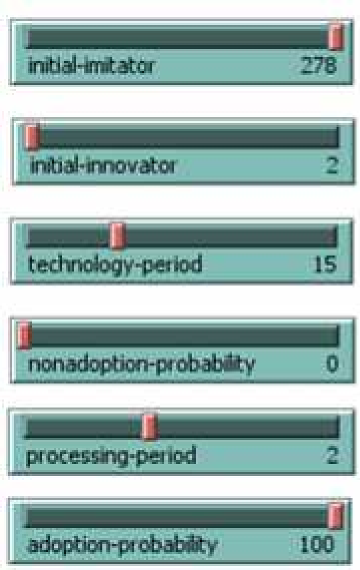


Figure 5. 11. Terminal point of the diffusion process

Previous diffusion models were based on the assumption that all the target group (cluster) will eventually adopt the technology. However, in practice this assumption may invalid because there are agents who may not be interested on the technology and even there may be an agent who don't get information about it.

5.2.1.2 Simulation Result of the Existing Situation

NETLOGO interface tab called slider is used to change the input variables and to see the different result appeared on the diffusion curve. In this model six sliders are sated having different functions during the simulation.



Initial-imitator slider: is used to set the number of initial imitative agents.

Initial-innovator slider: is used to set the number of initial innovative agents.

Technology-period slider: is used to set the threshold or optimum period of the specific technology

Nonadoption-probability slider: is used to set the percentage of probability in which an agent will not be willing to adopt.

Processing-period slider: is used to set the processing time for fully adopting technology by those willing agents.

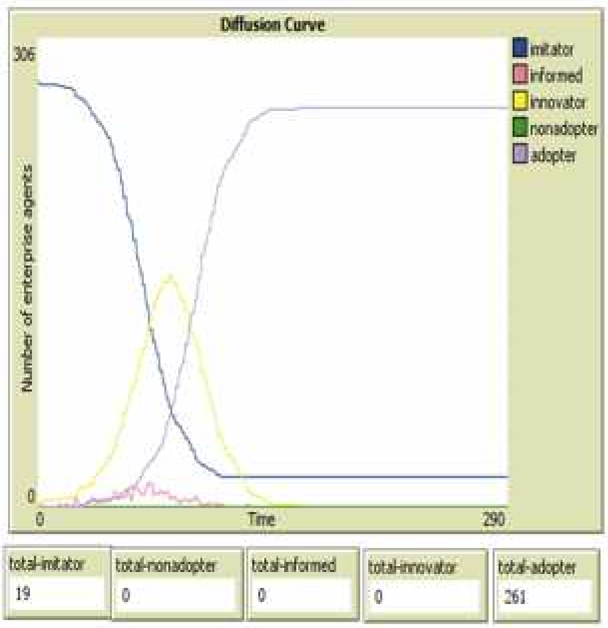
Adoption-probability slider: is used to set the percentage of probability in which an agent will be willing to adopt.

Parameters adjusted to draw existing diffusion curve for HDSM in EIFCCOS

The following are important parameters and time adjusted to fit the existing scenario of EIFCCOS.

- Initial imitators 278
- Initial innovators 2
- Probability of adoption 100% ,80%
- Probability of nonadoption 0% ,20%
- Technology (HDSM) period 15 years
- Processing period 4 months

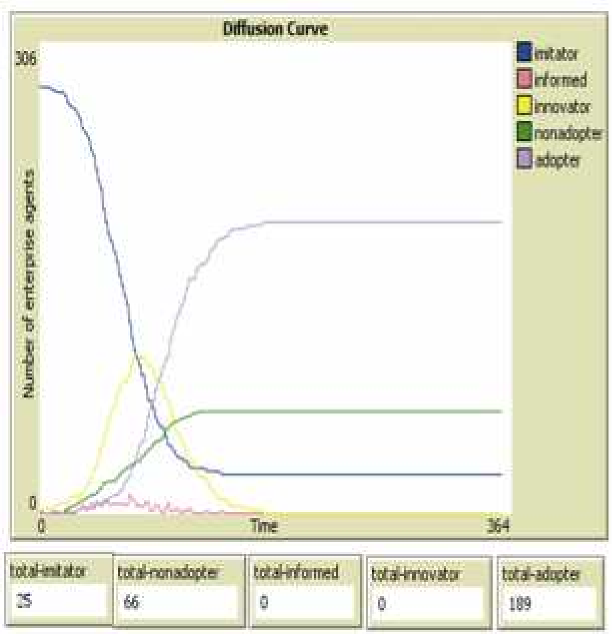
Based on the above parameters and time the following result is obtained. When the probability of adoption becomes 100% and nonadoption 0%, the diffusion time becomes around 3 years (on the graph as 290, 100 is taken as 1 year). And for the probability of adoption 80% and nonadoption 20%, the diffusion time result is around 4 years (364 on the graph). In addition, as the probability of nonadoption increases, the number of not informed agents also increased (on the first case it is 19 on the second increased to 25).



Adoption probability 100% and Nonadoption 0%

Adoption probability 80% and Nonadoption 20%

Figure 5. 12. Simulation result for diffusion of HDSM in EIFCCOS



5.2.2 Simulation Experiment

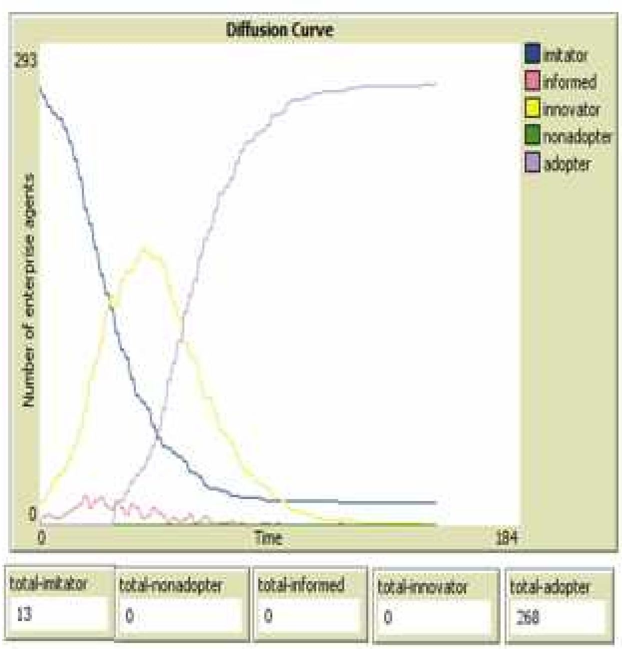
Depending on the above case it is possible to make an experiment on different scenarios. Three cases are taken and simulation is made and, on each parameter, different result is obtained for each experiment.

Experiment – One

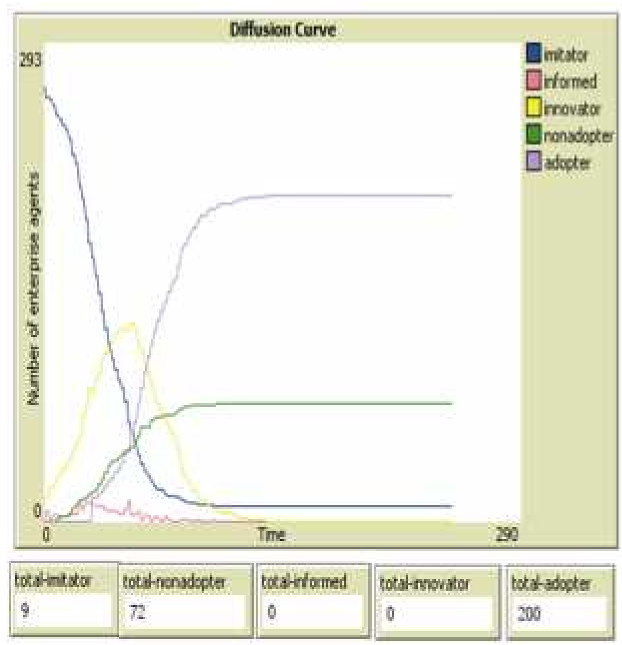
The first case checked through the simulation is the effect of increased number of initial innovative agents. This is done by assuming that the number of innovative enterprise agents increase because of high level of cooperation with supporting agents or it indicates there is an active participation of supporting agents to provide a triggering support for these innovator agents. The prioritized external diffusion factors are provided as a support, these are

- Financial support and
- Technical support

Adjusting or increasing initial- innovator slider, the simulation results in an accelerated rate of diffusion



15 initial innovators with 100% adoption probability



15 initial innovators with 80% adoption probability

Figure 5. 13. Experiment result with an increased number of initial innovators

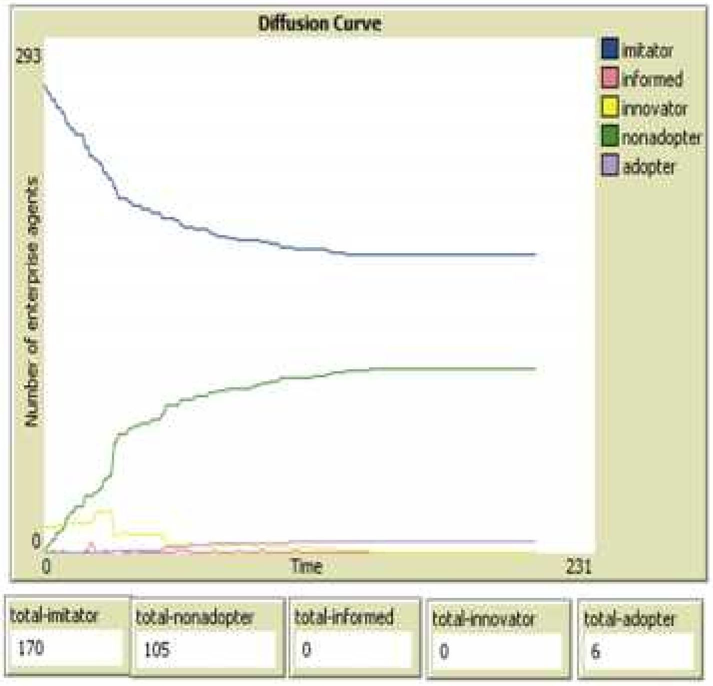
On the first graph initial innovators are increased from 2 to 15 with adoption probability 100% and it results decreased diffusion period from 2.9 years to 1.84 years the difference is visible. On the second graph initial innovators increased to 15 and probability of adoption 80%, probability of nonadoption 20% it results decreases diffusion time from 3.64 year to 2.9 year.

Experiment - Two

The second scenario is based on the theory of rational efficiency, "The more enterprises adopt the technology, the more knowledge about the technologies true efficiency is disseminated and vice versa." This can be linked with the following prioritized internal factors affect diffusion.

- Employees' absorptive capacity
- Technologies' relative advantage
- Firms' adoption strategy and
- Trust

This theory is tested in the simulation by adjusting the "nonadoption-probability slider" and "adoption-probability slider", by reducing the probability of adoption and increasing the probability of nonadoption. The result indicates that because of most of the informed agents don't adopt the technology (as a result of the above listed factors), there is an increased number not informed agent (at their original state as initial imitators).



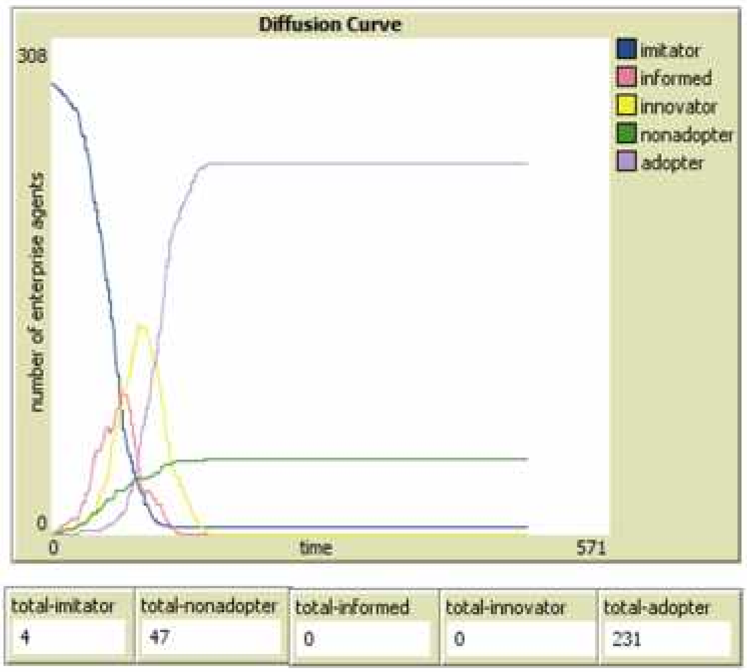
Since the adoption probability is less, imitator agents are not able to know about the advantage or disadvantage of the technology as a result most of the agents stay at their original state. As shown on the figure number of total adopters is 6, number of total imitators remains 170 and nonadopter 105. This indicates within the given time (2.3 years) the technology is almost not diffused.

Figure 5. 14. Experiment result with 20% adoption probability and 80% nonadoption probability

In addition, the above graph indicates the negative consequence of the absence of factors listed above. For instance, if the level of trust inside the cluster is weak then information about the true efficiency about that technology will not be distributed as a result there will not be a door for adopting or not adopting it.

Experiment – Three

The third experiment is takes placed to validate the critical importance of integrated support from all the stockholders (LIDI, DBE and AAIDO). In which an enterprise can adopt technology within a possible minimum time, if the case is not, then the processing period (the time taken to fully adopt, can be the time taken for procurement or machine installation and trainings) will be elongated. By this reason the diffusion time will also be increased. Taking similar parameters of the existing situation and adjusting the slider parameter “processing- time” as 9 months, results the following graph.



Informed agents (pink line) stays a long time on the process to become certain adopter. As a result, the simulation result clearly shows an elongated time of diffusion which is 5.7 years, almost 6 years. Technology processing period could be increased because of weak contribution one of the supporting agent, this shows the supporting skim should also need to be integrated.

Figure 5. 15. Simulation result of increased processing period (9 months) with 80% adoption probability

5.3. Discussions

From the extensive analysis done so far, important points are discussed about the benefits of the overall model and the simulation results. As the main objective of the research is to integrate industrial cluster development through accelerated diffusion of technology, this model benefits to overcome the practical problems identified and contributes to the course of study. Some of the possible benefits of this model are as listed below,

- Supporting strategies are included in the model since small and medium enterprise need support to adopt new technologies.
- Supporting agents are defied based on the critical factors identified from the AHP, (financial supports and technical support)
- Beside the supporting agents, enterprises are modeled by considering their heterogeneity or different adoption capacity as innovators and imitators

- Differently from the previous diffusion models adoption decision, this model includes fuzzy logic for the adoption decision. As it makes the implementation easy and compatible with real life scenario of SMEs
- The simulation model includes probability of adoption, considering the likelihoods of agent's adoption decision (fuzziness)
- Simulation result of existing situations brings shortest time of diffusion (3 years, with 80% adoption probability) and (4 years, with 100% adoption probability) compared to the Bass model result of 6 years.
- The first experiment result explicitly shows the effect of increased external supports both for the adoption and diffusion of technology.
- The second experiment result clearly indicated the effect of lack of trust and absorptive capacity on the dissemination of the true efficiency of the technology. which in turn slows the rate of diffusion
- The third experiment gives a clear insight about the importance of integrated support for the supporting agents. Because of lack of integrated support, the time taken to fully adopt the technology would be elongated, this affects the total diffusion time.
- All the three defined supporting agents (regulatory, technical and financial) need to have an integration or a clear platform for communication to reach to an enterprise agent, because active and integrated support highly affects the rate of diffusion. And reversely, weak participation of one of the supporting agent results a slow diffusion rate.
- Generally, the model leads enterprises and supporting organizations to work cooperatively and accelerate adoption of technology in the cluster to result an integrated development of enterprises.

Chapter Six

Conclusions and Recommendations

In this chapter conclusions, recommendations and future research directions of the whole research are explained in detail.

6.1 Conclusions

Manufacturing sector competitiveness is an ever-growing concern for government and firms in Ethiopia since it takes a lion's share for the sustainable development of the country. Focusing on the competitiveness of the sector has two core benefits on the first place, it can be a source for hard currency through exporting locally manufactured products and the other one is, it can substitute the local market with quality products which saves hard currency incurred for importing goods.

However, over the years the sector could not be competitive as it is expected to be. This is mainly because of lack of using new and advanced technologies for the manufacturing process to produce high quality products which can fit local and global quality product standard. Specially geographically clustered medium level manufacturing industries play a great role for the above-mentioned benefits. As a result, it is important to focus on the level of their technology utilization, adoption and diffusion through these clustered industries.

In this thesis an emphasis was given on the cooperation of industries with supporting organization (to adopt technologies) and on internal integration (to accelerate the rate of diffusion inside the cluster). To do so, identifying and measuring important endogenous and exogenous factors affect adoption and diffusion of technology was the first task. Among seven different manufacturing subsectors, leather and leather goods manufacturing subsector was selected with the highest weight.

Ethio-International Footwear Cluster Cooperative Society Ltd (EIFCCOS) was the case selected for this research. To quantify the existing rate of diffusion of technology in the cluster, one technology is selected (HDSM) and BASS diffusion model was implemented. The forecasted result indicates, for the machine to be diffused it takes around 6 years which is an elongated time for the case of geographically proximate industries.

Based on the existing result, the research tried to develop extended agent-based model of technology adoption and diffusion, a model which is the first of its kind for industrial cluster in Addis Ababa. Before doing so, prioritizing endogenous and exogenous adoption and diffusion factors was necessary therefor, using AHP decision making tool the factors were prioritized. Then the model constructed initially by defining three basic conceptual domains first, defining agents, then designing agent's interaction topology and their communication network finally, defining agent's adoption decision tree. For agent's adoption decision, fuzzy analysis of prioritized factors is done.

After defining conceptual futures, the next task was simulating the model in order to validate it. The simulation was done using a tool called NETLOGO 6.0.2. First existing situation in EIFCCOS was simulated taking the existing data (case for HDSM, 2 initial innovators and 278 initial imitators a total of 280 enterprises) in addition some important parameters were adjusted like processing period (the time taken for full adoption) to be 4 months, technology period 15 years, probability of adoption and nonadoption as 100%,0% and 80%,20% respectively. The result obtained was 3 years for diffusion including 19 initial not informed agents for 100% adoption probability and 3.6 approximately 4 years for 80% adoption probability with 25 initial not informed agents.

Furthermore, experiment of three different scenarios were simulated. The first case was to see the effect of increased initial innovator on the rate of diffusion since the simulation model assumes that an increased number of initial innovators results from external supports. And it results with decreased rate of diffusion (from 3 years to 2 years). The second case experimented was based on the flow of information about the technology inside the cluster here, the prioritized internal factors were considered. On 20% adoption probability within 2.3 years only 6 enterprises adopt and the rest remains as nonadopter. And the third on the effect of integrated support on technology processing time and diffusion time. The processing time slider was adjusted to 9 months with 80% adoption probability and it results to stay an informed agent a long time. This affects the diffusion year to be extended to 6 years.

Finally, to fill the gaps of the existing literatures, the study explores the available literatures on technology diffusion models and on this specific model it is tried to include supporting strategies for adoption and diffusion of technology in industrial cluster.

In conclusion, the findings of the research show that, for accelerated diffusion of technology inside clustered medium level manufacturing industries, there is a need for support from external learning, financial, and research institution to introduce enterprises with new technologies and also it is found that strong internal interaction between enterprises is a key for integrated development.

6.2 Recommendations

Technological advancement for medium level clustered manufacturing industries demands the effort of all the stockholders around them. The research has demonstrated the need for cooperation and internal integration is critical for accelerated adoption and diffusion of technology that leads to an integrated development. Based on the results obtained, the following recommendations are forwarded for the stockholders to accelerate the current adoption and diffusion of technology for medium level clustered manufacturing industries.

- Supporting innovator enterprises by providing technical supports (visibility study, machine maintenance, installation, product quality testing and certifying, introducing new designs, and research and development) and financial support to enable them to adopt new technologies. Based on this, LIDI, DBE and AAIDO are recommended the following points
  - For all the three supporting agents, integration (clear communication) is a critical point for effective technology adoption and diffusion. Since the weak contribution of the single supporting agent affects the whole system.
  - LIDI need to have standardized supporting schedule of these medium level leather and leather product manufacturing industries (the institution provides supports only based on the industries request). And the same for the other subsectors supporting institutions.
  - DBE need to provide trainings about the concept of lease financing and the overall Loan culture of the SMEs. As a policy recommendation, expecting these SMEs to Support the export market and source of hard currency is good but shouldn't be putted as a prerequisite to get a loan.
  - AAIDO need to actively facilitate interconnections of the above institutions with industries through providing policies and setting the network between industries and institutions.
  - Other institutions like industry extensions and universities also have to be active participant on supporting these industries.

- Inside the cluster Imitator enterprises need to have the following collaboration platforms for accelerated diffusion of technology
    - Owners (management) of an enterprise should focus on employees' absorptive capacity since it is high priority factor. Most of employees are not professional rather they work based on the experience they acquire gradually
    - It is important to build trust both between employees and owners to disseminate information of new technologies between firms, because to decide to adopt or not, first they need to have an information about it
    - Firms (owners) need to have positive attitude towards competition inside the cluster, if this is so, their technology adoption strategy will lead them to integrated development
- Finally, the unique future of the model developed in this thesis is, it considers both heterogeneity and homogeneity of industries. Sticking on clustered industries under the same sector or manufacturing similar products is their homogeneity. On the other hand, their innovativeness and imitativeness or an attention they give on seeking new technologies from external environment indicated their heterogeneity. Likewise, this specific model can be implemented in any medium scale clustered manufacturing industries found around urban areas of Ethiopia by making some modifications.

6.3 Future Research Direction

During conducting this thesis, it has provided various insights in demonstrating pathways for further investigation and study of the area. Accordingly, the following future research directions are identified in the course of the study. These are,

- In this thesis adoption network considered is as innovator enterprises adopt technology from research and learning institutions by assuming, the institutions as either a source of technology or transferring channel. However, it is also possible to develop direct interaction network of these medium clustered manufacturing industries with large and multinational industries (industrial parks, special industry zones etc.). Which will open another opportunity for SMEs to adopt modern technologies.

- The model can be extended by including the economic benefits gained for early adopters because of early market penetration with a new product.

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Sahin Ismail (2006) “Detailed review of rogers’ diffusion of innovations theory and educational technology-related studies based on rogers’ theory”

Sarkar Jayati (1998) “Technological diffusion: Alternative theories and historical evidence.”

Shapira Philip and Rosenfeld Stuart (n.d) “An overview of technology diffusion policies and programs to enhance the technological absorptive capabilities of small and medium enterprises”

Sillah Bukhari M.S. (2014) “Human capital, foreign direct investment stock, trade and the technology diffusion in Saudi Arabia” 1974-2011

Silverberg, G. Dosi G. and Orsenigo L. (1988) “Innovation, diversity and diffusion: a self-organizing model.”

Silvestre Bruno S. & Netob Romeu Silva (2013) "Capability accumulation, innovation, and technology diffusion": Lessons from a Base of the Pyramid cluster

Singhal A, & Dearing, J.W. (2006) "Communication of innovations" A journey with Ev Rogers. Thousand Oaks, CA: Sage. An edited book

Soo Wook Kim & Kanghwa Choi (2009) "A Dynamic Analysis of Technological Innovation Using System Dynamics"

Tae-Hyung Pyo, Gary Russell & Thomas S Gruca (2012) "A new Bass model utilizing social network data"

Ting Zhang, Sonja Gensler, and Rosanna Garcia (2011) "A Study of the Diffusion of Alternative Fuel Vehicles: An Agent-Based Modeling Approach"

Tom G. and Van der V. (2008) "Defining SMEs: a less imperfect way of defining small and medium enterprises in developing countries"

Wei Jia liu Li-ran and Xue XIE mei (2010) "Diffusion of technical innovation based on industry-university-institute cooperation in industrial clusters"

Wolday Gebremichael and Tassew Ayalneh (2015) "Small and medium manufacturing enterprises for sustainable development and job opportunity in developing countries"

Worku Tuffa Birru (2011) **"**Horizontal inter-firm cooperation in Ethiopian small and medium enterprises" Evidence from leather shoe manufacturing firms in Addis Ababa

Zhang T. & Zhang D. (2007) "Agent based simulation of consumer purchase decision making and the decoy effect"

ANNEX -A: Model programming code

```
;;technology diffusion Model for industrial cluster ver.2
;;This model simulates the diffusion of technology between innovator and imitator enterprise agents traveling via contact through a randomly moving enterprises (owners).

breed [imitator imitators];;Different breeds of turtles to show heterogeneity
breed [informed  informeds]
breed [innovator innovators]
breed [nonadopter nonadopters]
breed [adopter adopters]

globals [ ;; Global variables.
  total-imitator
```

```
  total-innovator
  total-informed
  total-nonadopter
  total-adopter
]

turtles-own [  ;; Turtle variables.
  turn-check
  wall-turn-check
  processing
  innovativeness
  adopter-check
  nonadopter-check
]

to building-draw ;; Use the mouse to draw buildings.
  if mouse-down?
    [
      ask patch mouse-xcor mouse-ycor
        [ set pcolor grey ]]
end

to setup  ;; Initialize the model.
  clear-turtles
  pop-check
  setup-agents
  update-globals
  do-plots
end

to go  ;; Run the model.
   technology-check
   repeat 5 [ ask imitator [ fd 0.2 ] display ]
   repeat 5 [ ask informed [ fd 0.2 ] display ]
   repeat 5 [ ask innovator [ fd 0.2 ] display ]
   repeat 5 [ ask nonadopter [ fd 0.2 ] display ]
   update-globals
   do-plots
```

```
  reset-ticks
end


to setup-agents   ;;Setup the beginning number of agents and their initial
state.
  set-default-shape imitator "person"
  set-default-shape informed "person"
  set-default-shape innovator "person"
  set-default-shape nonadopter "person"
  set-default-shape adopter "person"

  ask n-of initial-imitator patches with [pcolor  = black]
     [ sprout-imitator 1
      [ set color blue ] ]

  ask n-of initial-innovator patches with [pcolor = black]
    [ sprout-innovator 1
      [ set color yellow
        set innovativeness technology-period ] ]

end

to technology-check ;;   Check to see if an informed or innovator turtle
occupies the same patch.
  ask imitator[
    if any? other turtles-here with [color = yellow]
    [inform]
    if any? other turtles-here with [color = pink]
    [inform]
    wander
  ]

  ask innovator[
    if any? other turtles-here with [color = blue]
    [inform]
    wander
    set innovativeness innovativeness - 1
```

```
    if innovativeness = 0
    [nonadopt-or-adopt]
  ]

  ask informed[
    if any? other turtles-here with [color = blue]
    [inform]
    wander
    set processing processing - 1
    if processing = 0
    [get-innovator]
  ]

  ask nonadopter[wander]

end

to inform ;;  inform an imitator turtle, check if it don't adopt and set the processing timer if it is going to adopt the technology.
  set nonadopter-check random 100
  if else nonadopter-check < nonadoption-probability
  [nonadoption]
  [ask imitator-on patch-here[
    set breed informed
    set processing processing-period]
  ask informed-on patch-here [set color pink]]

end

to get-innovator ;;  Change an informed turtle into an innovator turtle and set the technology timer.
   set breed innovator
   set color yellow
   set innovativeness technology-period
end

to adopt ;;to adopt a turtle who reaches the end of the decision once it gets informed.
```

```
  set breed adopt
  set color violet
end

to nonadopt-or-adopt ;; Test if the turtle adopt the technology
  set adoption-check random 100
  if else adoption-check < adoption-probability
  [adoption]
  [nonadoption]
end

to nonadoption ;;  Change turtle breed to nonadopter.
  set breed nonadopter
  set color green
end


to wander ;; Random movement for agents.
    set turn-check random 20
    if turn-check > 15
    [right-turn]
    if turn-check < 5
    [left-turn]
     if [pcolor] of patch-ahead 1 != black
     [wall]

end

to wall ;;  Turn agent away from wall
    set wall-turn-check random 10
    if wall-turn-check >= 6
    [wall-right-turn]
    if wall-turn-check <= 5
    [wall-left-turn]
end

to wall-right-turn ;;Generate a random degree of turn for the wall sub-
routine.
```

```
  rt 170
end

to  wall-left-turn  ;;Generate  a  random  degree  of  turn  for  the  wall  sub-
routine.
  lt 170
end

to right-turn ;;Generate a random degree of turn for the wander sub-routine.
  rt random-float 10
end

to left-turn   ;;Generate a random degree of turn for the wander sub-routine.
  lt random-float 10
end

to update-globals ;;Set globals to current values for reporters.
  set total-imitator (count imitator)
  set total-informed (count informed)
  set total-innovator (count innovator)
  set total-nonadopter (count nonadopter)
  set total-adopter (count adopter)
end

to do-plots ;; Update graph.
  set-current-plot "Diffusion curve"
  set-current-plot-pen "imitator"
  plot total-imitator
  set-current-plot-pen "informed"
  plot total-informed
  set-current-plot-pen "innovator"
  plot total-innovator
  set-current-plot-pen "nonadopter"
  plot total-nonadopter
  set-current-plot-pen "adopter"
  plot total-adopter

end
```

```
to pop-check  ;; Make sure total population does not exceed total number of
patches.
  if initial-imitator + initial-innovator > count patches
    [ user-message (word "This simulation only has room for " count patches "
agents.")
      stop ]
end
```

Credit for the original code

The original code was developed as a part of research work for The Center for Complexity in Health at Kent State University Ashtabula as “complexity Geek” by Michael D. Ball. I used the models’ programming code as a base for this research by redefining the basic parameters, Turtles global variables and the plot result as well.

ANNEX – B: Summary of key Articles Reviewed on Models of Technology Diffusion and Integration of Industrial Cluster

No	Author	Title	Problem	Methodology	Result	Gap	Tools
1	K. Usha Rao & V.V.N. Kishore (2010)	A review of technology diffusion models with special reference to renewable energy technologies	Limited application (20-25%) of renewable energy technology of different products like automobile and television	By reviewing different documents related to models of technology diffusion to integrate renewable energy technology to different products manufacturing.	The application and development of diffusion models were only concerned to commercial products or processes but it should also be useful for renewable energy technology	Not focused on the specific issue of developing a model of technology diffusion for renewable energy technology, it only indicates that there should be a model similar for other manufacturing firms	Integration of Bass and Mansfield models
2	Bruno S. Silvestre & Romeu e Silva Netob, (2013)	Capability accumulation, innovation, and technology diffusion: Lessons from a Base of the Pyramid cluster	Lack of framework that will incorporate the context, challenges, and dynamic nature of the industrial clusters limited knowledge and accumulated within firms compared to clusters elsewhere	Case study research method conducted in traditional granite mining cluster in brazil, 154 interviews with key informants between 1999 and 2011	From the developed framework that encountered the dynamic nature of BOP cluster, identified the reason that it is because of the existence of barriers for technology diffusion like lack of coordination and misaligned policy approach	For developing the theoretical framework, the paper only considers the dynamic nature of BOP cluster wit out looking other factors.	Data analyzed through conflicted ideas of stakeholders
3	Thomas Brychan (2000)	A model of the diffusion of technology into SMEs	SMEs have disadvantages related to the lack of technological and financial resources which can lead not only to problems in their ability to source technology but also in their capability to	Taking theoretical assumptions of different diffusion models, develops a model to customize for SMEs.	A model of technology diffusion is developed by taking the existing technology and innovation the model considers external sources, channels of technology transfer, and	The model is based on between the source of technology and the destination (SMEs) in which it doesn't include inter firm diffusion (from one SMEs to the other).	Bass DM Tables, algebraic formulas

			absorb it into their organization and diffuse it into their industrial sector (Jones-Evans, 1998).		mechanisms involved in the transfer of technology into the innovative SME.		
4	Wei, LIU Li-ran and Xue-mei (2010)	Diffusion of technical innovation based on industry-university-institute cooperation in industrial clusters	Most of the time Enterprises in industrial clusters are not capable of independent in an innovation and technology resulting to less competent	Simulation and analysis is takes place of the internal and external factors of innovation diffusion in to industrial clusters	The simulation result indicated that when most of the enterprises have no R&D capability or limited capability, Industry-University-Institute Cooperation can promote the emergence of technical innovation in the industrial cluster.	keeping the result is strong and reliable, it may weaken the ins and between enterprises innovation diffusion since their link will be only with university and institutes	Cellular automation model
5	Michael Hubler (2010)	Technology diffusion under concentration and convergence	Chinas global economic integration strongly affects its growth and also resulting environmental impacts.	Focused on mainland china energy specific technology diffusion mechanism Benchmarking and calibration are also done.	Introduce a mechanism of international technology diffusion via FDI and trade in to CGE modeling for climate policy analysis.	Since the model is climatic policy model, there are uncertainties of functional forms and parameter values.	DART model, PHOENIX model
6	Imen Daoud Naanaa &Fethi Sellaouti (2015)	Technological Diffusion and Growth: Case of the Tunisian Manufacturing Sector	Slowness of the diffusion of technology affects the total factor productivity of the country	The research is conducted in five manufacturing industry in Tunisia for the period 1970–2012.	The results suggest that openness to foreign companies and the Trade in Information and Communication Technologies (ICT) had a significant role in the diffusion of technology but the presence of foreign firms has not been a vehicle for	Limited ways are indicated or recognized as a vehicle for technology diffusion which is mainly ICT	TFP measures Cobb-Douglas production function

					technology diffusion for the Tunisian manufacturing sector.		
7	Bukhari M.S. Sillah (2014)	Human capital, foreign direct investment stock, trade and the technology diffusion in Saudi Arabia 1974-2011	There is a lack of research conducted on identifying up to date factors of technology diffusion since the country is growing faster	Employs co-integration method to analyze the long run relations between the technology diffusion and its determinants The data is collected from secondary sources.	Technology is an endogenous variable in the presence of human capital; and that the higher levels of educational attainments are found to significantly improve factor productivity The capital goods import and the domestic R&D expenditure are found to be negatively associated with the technology diffusion.	A further research is needed to provide additional evidence for the type of role the determinant factors play in the technology diffusion.	Time series econometric Co-integration
8	Richard R. Nelson	A "DIFFUSION" model of international productivity differences in manufacturing industry.	The differences of countries (developed and developing) regarding manufacturing productivity or output per worker	First a theoretical case for abandoning two central assumptions of the previous theory then an empirical analysis done finally comparison analysis of Colombian and Us	examines certain important difficulties with existing formal theory purporting to explain international differences in output per worker in manufacturing, particularly differences between developed and underdeveloped countries	On the argument reached which is technology diffusion process model should consider inter and international case but it shouldn't be like that	Elasticity analysis, CES equation
9	Murzidah Ahmad Murad and John Douglas	The importance of technology diffusion in Malaysian Manufacturing	Malaysian manufacturing SMEs is less than effective, or that less than competent.	Semi structured interviews were conducted with the decision makers of four Malaysian manufacturing companies	Identifies reasons for adopting or not adopting new technology into their business operations	The methodology used to conduct the research is not enough or strong to give the conclusion.	Result of Semi structured interviews

	Thomson (2011)	SMEs					
10	Rashed M. Al-Thawwad (2008)	Technology Transfer and Sustainability - Adapting Factors: Culture, Physical Environment, and Geographical Location	Lack of skilled technicians and the shortage of spare parts.	Measuring physical environments, cultural and infrastructural support, and geographical locations was thoroughly researched and developed.	culture, physical environment, and geographical location all have significant effects on technology transfer	Didn't determine the relationship between perceptions of culture, physical environment, geographical location, and the success of technology transfer.	survey instrument based on questions derived from available literature person product-moment correlations and simultaneous regression
11	P.A. Geroski (2000)	Models of technology diffusion	Things not considered in different technology diffusion models epidemic model, Probit model, density dependent and information cascades	Literature survey by focusing on alternative explanations of researchers on the models reviewed	Explains the premises behind each 4 models reviewed	-----	Literature review
12	John Liu (2000)	Theory and Methodology On the dynamics of stochastic diffusion of manufacturing technology	Thinking of technology diffusion, the manufacturing and marketing issues were not looked separately MTD should emphasize the manufacturing regularity and uncertainty	Flexible manufacturing is applied First derive a drift function in the context of MTD and address the drift-only. MTD model develop a model of manufacturing technology diffusion by adopting stochastic differential equation.	Optimal control is found for the regulation of MTD MTD model is proposed which will regulate MTD under uncertainty Prove the optimality of early technology phase-out. Augmented Hamilton-Jacobi variational equation for the	Since the research is starts from the gap that manufacturing technology is different from marketing technology it is difficult to draw a conclusion since the MTD model, the optimality control policy and the equation for the model are	Variation calculus, Ito's formula, stochastic differential equation

					solution of the MTD model.	only based on flexible manufacturing.	
13	Ai-Ting Goh (2004)	Knowledge diffusion, input supplier's technological effort and technology transfer via vertical relationship	Variation of countries development rate due to the cost incurred by developing countries to transfer and mastery of new technology through licensing, FDI and subcontracting	Starts by constructing assumptions to develop model	From the model constructed it is known that the importance of LDC supplier's technological effort for quality products in determining the impact of knowledge diffusion on technology transfer.	-----	Mathematical tools and variables
14	Sandra Robinson (2009)	Innovation Diffusion and Technology Transfer	----	The literature is written by comparing different authors finding of related works on different years.	Address innovation diffusion and technology transfer and Look at three other annotated literature reviews that form a foundational framework for the New Transparency Integrated Research Sub-Project 1 (IRSP I)	-----	Literature review
15	Philip Shapira and Stuart Rosenfeld	An overview of technology diffusion policies and programs to enhance the technological absorptive capabilities of small and	---	Overview of technology diffusion by taking 8 developed countries approach and policy for a case of SMEs.	Point outs 13 measures of technology diffusion and also Measures of technological absorptive capabilities of firms by looking at business and social infrastructures.	---	Related Literatures and qualitative data from secondary sources

		medium enterprises					
16	Jayati Sarkar (1998)	Technological diffusion: alternative theories and historical evidence	-----	Comparative literature survey of epidemic, neoclassical equilibrium and evolutionary disequilibrium models	Presents an interpretive survey of the neoclassical and evolutionary approaches to modeling the process of technological diffusion	------	Literature review
17	Rui Baptista (2000)	Do innovations diffuse faster within geographical Clusters?	Variation of adopting new technology by the factor of geographical location	The data set covers six three-digit 4 industrial sectors. Two technologies were selected TD model developed	Existence of significant regional learning effects on adoption and from the table a positive effect on increased adoption speed	The model doesn't consider individual firm's variable rather an aggregated dada is used which indicate an observed heterogeneity	Descriptive statistics, pseudo-residuals test,
18	Dahl and Pedersen (2004)	Knowledge flows through informal contacts in industrial clusters	There are claims that how knowledge will be diffused through informal social networks since the employee should be loyal to the firm	In one selected cluster by taking a sample of engineers asked a questioner as a survey	Informal contacts are important sources of knowledge for the engineers in their daily working life inside the cluster it is an important factor for knowledge diffusion.	Comparison should be done with other sources of information like internet, colleagues in their workgroup, technical journals rather than only considering informal contacts	Developed hypothesis, charts and tables to analyze the response of engineers
19	Piero Morosini (2004)	Industrial clusters, knowledge integration and performance	The concept of thinking that clustering is a matter of being together or proximity (ignoring integration)	Using a hypothesized argument on different dimensions and testing the hypothesis then developing arguments	The analytical framework and the testable hypothesis developed shows the social dimensions which are very important for the competitiveness of industrial clusters	As a further work he puts that a formal test of the hypothesis will lead to another important research area (he didn't test the hypothetical framework formally)	Tables, charts of hypothesis
20	Massimo et.al	An Innovative	Low level of integration of	Analysis done on three industrial	An idea developed to better	The research is based on a project	CSR tools

	(2010)	Model to Promote CSR among SMEs Operating in Industrial Clusters: Evidence from an EU Project	SMEs with all stockholders focusing on corporate social responsibility since societal problems affects the enterprises effectiveness and efficiency	clusters found in Tuscany Italy a working group created in each cluster with the goal of designing and implementing a territorial cooperative approach to CSR	understand the opportunities to formalize corporate social responsibility (CSR) practices for small and medium enterprises (SMEs) in a clustered system. Identify the role of the intermediary institutions (such as trade unions, local authorities, business consortia) in the cluster.		
21	Amare Abawa Esubalew (2017)	Micro, Small and Medium Enterprises(MSMEs)Development Strategies in Ethiopia	A problem on the Ethiopian micro, small and medium enterprises policy and strategy focused from 1997-2025 in which the focus is on the establishment of micro enterprises not on developing graduated middle enterprises	Based on secondary data, the retrospective and prospective analysis of MSMEs development strategies in Ethiopia was made	Ethiopian government need to make adjustment on the total asset with the GDP growth rate for MSMEs Need to see and support the progress of the level of enterprises Micro finance institutions should be supported by commercial bank since they are finance constrained	-----	Qualitative data analysis tools Secondary data
22	Worku Tuffa Birru (2011)	Horizontal inter-firm cooperation in Ethiopian small and medium enterprises	Lack of cooperation among firms of similar sector and lack of awareness about the importance of inter firm cooperation beyond to fill the financial gap.	The data used in this study is collected from September 2007 to February 2008 from 100 small and medium-sized leather shoe manufacturing firms operating in Addis Ababa, Ethiopia.	Negative perception to competition and lack of trust to partner firms are factors that hinder effective cooperative relationship among competing firms. most firms operate not in isolation, but in collaboration with other firms at the same stage of a value chain	Since the research area is new, the data analysis is not strong and the result also, it was better if the research ends up with tangible output rather than only identifying the factors	Mean and standard deviation, SPSS 15^{th} version

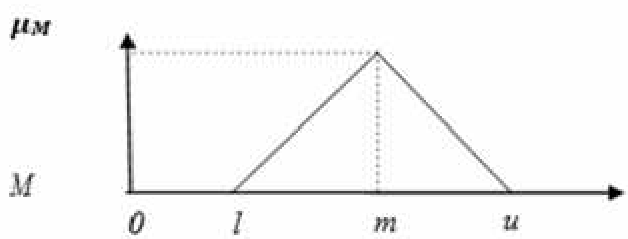
ANNEX -C: Summary of constant scales and formulas taken

Table: Saaty's Scale of Importance

Strength of importance Description	**Strength of importance Description**
1	Equal importance
3	Weak importance
5	Strong importance
7	Very strong importance
9	Absolute importance
2, 4, 6, 8	Intermediary values between the

A triangular fuzzy number (TFN), analysis formulas

$$\mu_M x = \begin{cases} 0, & x < l \\ \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0, & x > u \end{cases}$$



(1)

Figure: Membership function of a triangular number

For any two triangular fuzzy numbers and M_1 and M_2, $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$,

$$(l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

$$(l_1, m_1, u_1) * (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \quad (3)$$

$$(l_1, m_1, u_1)^{-1} = (1/u_2, 1/m_2, 1/l_2) \quad (4)$$

ANNEX - D: Data Collection Tools
Semi structured Interviews

Addis Ababa University
Addis Ababa institute of technology
School of mechanical and industrial engineering

Greetings from the Addis Ababa University, Institute of technology! With the approval of the Addis Ababa Institute of Technology, I am conducting a thesis work for a fulfillment of my MSc degree program in Industrial Engineering entitled "**Modeling Technology Diffusion to Integrate Medium Scale Clustered Manufacturing Industries Development**". The purpose of this research is to Develop technology diffusion model which will accelerate clustered industries technology adoption rate by integrating enterprise with the support value system in order to enhance the enterprises' technology adoption capacity and faster diffusion of technology. Therefore, I would like to request you to participate in this research because I believe that your experience in the sector would help us much. Please answer the questions freely **every information provided will be treated in the strictest confidence**. The interview will take about 30 minutes to complete. Your genuine responses are essential to build an accurate picture of the issues that are of utmost importance for this research.

For any enquiry, please contact:

Researcher: Mehret Getachew +251-943-65 10 37

Advisor: Dr.-Amha Mulugeta (PhD) +251-911-94 80 14

Co-advisor: Mr. Fitsum Getachew (PhD candidate) +251-913-95 21 63

Thank you in advance for your time and genuine response.

Semi-Structured Interview Questions for LIDI, AAIT-UIL and IEO

Please state your name, managerial post and educational background for the record.

1. What is your level of involvement in supporting industrial clusters?
2. What do you believe is your role for technology adoption and diffusion in enterprises within industrial cluster?
3. Do you think it is important to provide R&D and technical training to enhance enterprises technology adoption capacity?
4. How do you support enterprises, is it by giving technical training, providing R&D or by supervising what they are doing? (please give detailed support structure and procedure)
5. Is there any structured schedule to support the enterprises? If so How often do you give technical training for the enterprises?
6. How do you see the importance and relevance of working corporately with industrial clusters in building technological capability and accelerating technology diffusion inside the enterprises?
7. What seem to be the hindering factors (obstacle) in supporting enterprises capability development?
8. What measures are taken by your institute and your office in particular to build technological capable enterprises?
9. How do you see the importance of enterprises technological capability regarding faster diffusion of technology in the cluster?
10. What level of attention is given to support SMEs as compared to large industries?
11. If your response is no then, what do you think is the major reason?
12. What do you think is the role of this enterprises in being source of technology?
13. Is there any operational capability support, maintenance activities support to enable the enterprises as innovators?

Semi-Structured Interview Questions for Addis Ababa Industry Office and Federal small and medium enterprises development agency

1. What is the major role of the office with respect to enterprises technological capability development?
2. Which supporting organizations are major entities involved in the building technological capability of the enterprises and how are they involved?
3. What are the hindering factors for the enterprises less technological capability?
4. How do you think governmental policy affects the enterprises to adopt value adding technologies?
5. What are the regulatory tasks undertaken by the office?
6. As compared to large firms, is there a special attention given to SMEs?
7. Is there any platform developed for collaboration between enterprises?

Semi-Structured Interview Questions for financial institutions (Development bank of Ethiopia)

1. Can you briefly describe the overall current loan process for the SME enterprises development?
2. What are the major prerequisites expected from the enterprises to get a lone for the purpose of new equipment or machinery?
3. Are there any specialized provisions of loan and other supports for firms within nationally formed clusters?
4. What do you think is the major constraints for your institution that makes the loan getting process tough?
5. What do you think should be done to address above mentioned problems/challenges?

Structured Interview (survey) of Enterprises to measure adoption rate of HDSM technology

1. Do you use heavy duty stitching machine for your manufacturing process?
2. If your answer for question 1 is yes then, how you adopted the technology

a) Internal source (where the technology was already in use by other enterprises in the cluster)
b) External source (the technology was not used by other enterprises in the cluster before and adopted from external source)

3. If your answer for question 2 is from internal source, then select the specific source
   a) Own effort to identify technology
   b) Other enterprises in the cluster
   c) Specify if any
4. If your answer for question 2 is from external source, then select the specific source
   a) Research institutions
   b) Other firms outside the cluster
   c) Technology supplier
   d) The internet
   e) Specify if any

Questionnaires

Semi structured Questionnaire to measure the internal factors affecting technology adoption

For the owner or management personnel

Part I: Basic Company Profile

Name of enterprise: ____________________________________

Level Small/medium: ____________________________________

Respondent position: ____________________________________

Respondent educational background: ____________________________

Part II: Enterprises behavior or working culture and integration with other enterprises

Please rate the descriptions of indicated factors by putting (X) mark on values from 1 to 5 (1 to mean not available and 5 very strongly available)

No	**Description of factors**	1	2	3	4	5
1	willingness of your employees to learn from other enterprises in the cluster					

2	Willingness of your enterprise to learn other enterprises in the cluster					
3	Good working culture in the enterprise to empower employees for adopting technology					
4	Enterprise's training culture to enhance employees adopting capability					
5	Importance of research and development for the enterprise					
6	Importance of training for the enterprise					
7	Enterprises research and development expenditure					
8	Trust between enterprises regarding shearing technical knowhow					
9	Enterprise's adoption strategy or the focus given for technology adoption					
10	Competition between enterprises to come up with value added product					
11	Positive effect of clustering or geographical proximity for technology diffusion					
12	Negative effect of Culture or social barriers on technology adoption and diffusion					

Part III: Enterprises working culture with supporting institutions

1. Is there collaboration culture of the enterprise to work with knowledge institutions?
2. If yes, what are the means of collaboration with learning institutions?
   a) They provide training periodically
   b) They provide research and development
   c) Comment provision on work we have done
   d) They supervise our work
   f) Other (Please specify) ________________________

3. Among the following learning institution, which one is well cooperatively working with you?

a) Universities

b) Industry extension office (TVETs)

c) Specify if any

3. Among the following research institution which one is well cooperatively working with you?

a) Lather industry development institute (LIDI)

b) Specify if any

5. Do you think financial constraint is more influential factor for your enterprises adoption strategy?
6. Is there a means that you get support from financial institution to adopt new technology?
7. Which financial institution is mainly supporting your enterprise in order for the procurement of a new machine or any other technology?
8. From the following, for which supporting institution do you give more weight for the overall technological development of enterprise?
    a) Financial institutions
    b) Learning institutions
    c) Research institutions
    d) Regulatory institutions

Structured questionnaire for Pairwise comparison of internal factors (for owners)

Put check marks on the pair-wise comparison matrices for employee behavior (EB), technology attribute (TA) and firm behavior (FB).

Importance (or preference) of one factor over another											
No	**Criteria**	Extremely important	Very strongly important	Strongly important	Moderately important	Equally important	Moderately important	Strongly important	Very strongly important	Extremely important	**Criteria**
1	EB										Trust
2	EB										Informal contact
3	EB										Absorptive capacity
4	EB										Culture
5	TA										Complexity
6	TA										Compatibility
7	TA										Relative advantage
8	FB										Firm strategy
9	FB										Cooperation
10	FB										Competition

Structured questionnaire for Pairwise comparison of external factors

Put check marks on the pair-wise comparison matrices for external support (ES) and social environment (SE).

Importance (or preference) of one factor over another											
No	**Criteria**	Extremely important	Very strongly important	Strongly important	Moderately important	Equally important	Moderately important	Strongly important	Very strongly important	Extremely important	**Criteria**
1	ES										R&D
2	ES										Training
3	ES										Financial support
4	ES										Technical suppose
5	ES										Regulatory
6	SE										Geographical proximity
7	SE										Social barrier

Semi structured Questionnaire for employees of the enterprise

Part I: Employee Personal Information

1. Your professional background: ---
2. Please indicate your educational level

a) High school

b) College diploma

c) B.Sc/BA. degree and above

Part II: Employees behavior or working culture

1. Do you believe that working cooperatively affects the adoption rate of new or existing technology?
2. Rank the following activities in their contribution to technology adoption and diffusion in your working area (Please use: ‘3’ - very important, ‘2’ - moderately important and ‘1’ - fairly important)

a) Own effort ______

b) Informal contact ______

c) Training Efforts ______

3. Which of the following is more challenging to adopt and learn new technology easily?
   a) If it is complex and difficult to understand how to operate or how to implement
   b) If it is not Compatible to our manufacturing process
   c) If it's benefit or outcome is not Visible
   d) Specify if any
4. How would you rate the level of openness/trust between your colleagues?
   a) High
   b) Medium
   c) Low
   d) None
5. How frequently do you contact your colleagues informally?
   a) Every day
   b) Some times
   c) Rarely
   d) Not at all
6. How would you rate your culture (perception or attitude) regarding transferring knowledge and technical knowhow to your colleagues?
   a) High
   b) Medium
   c) Low
   d) None
7. Do you share information about your working environment when you meet informally?
8. If your answer for question 8 is yes then, how do you compare it with sharing knowledge with colleagues formally in the working time?
9. How do you see the social or cultural barriers to share knowledge?

አዲስ አበባ ዩኒቨርሲቲ
አዲስ አበባ ቴክኖልጂ ኢንስቲትውት
የሜካኒካሌ እና ኢንዱስትሪያሌ ምህንድስና ትምህርት ቤት
የኢንዱስትሪያሌ ምህንድስና የድህረምረቃ ፕሮግራም

ርዕስ: "Modeling technology diffusion for integrated development of industrial cluster"

ስም፡ ምህረት ጌታቸዉ ስሜ

አድራሻ፡ አ.አ ስልክ፡ 0943 65 10 37

ኢ-ሜል፡ mihretgetachew2015@gmail.com

ምስጋና

ይህ መጠይቅ የተዘጋጀው የ MSc. የጥናታዊ ጽሁፍ መረጃ ለማጠናቀር ሲሆን ከመጠይቁ የሚገኙት ምላሾች በጥንቃቄና ሚስጢራዊነቱ በተጠበቀ መንገድ የሚሞሊና የሚቀመጥ ነው፡፡ ይህንንም ግምት ውስጥ በማስገባት መጠይቁን ሲሞለ በነጻነትና በትክክለኛ መንገድ እንዲሞለ በአክብሮት ስጠይቅ ጥናቱን በተመለከ ማንኛውንም አይነት ጥያቄ ካላችሁ የሜካኒካሌ እና ኢንዱስትሪያሌ ምህንድስና ትምህርት ክፍለን ማነጋገር እንደምትችለ እየገለጽኩ መጠይቁን በመሙላት ለምታደርጉት ቀና ትብብር በቅድሚያ በራሴና በትምህርት ክፍሉ ስም አመሰግናለሁ፡፡

ምህረት ጌታቸዉ

ቴክኖሎጂን ለመዉሰድና ለመላመድ ምክንያት የሚሆኑ ዉስጣዊ ነገሮችን በተመለከተ የቀረቡ ጥያቄዎች

ለ ድርጅቱ ስተዳደረ ሰራተኛ ወይም ለባለቤት

የድርጅቱ ማንነት፡

የድርጅቱ ስም፡ ---------------------------

ደረጃ ነስተኛ/ መካከለኛ፡ ---------------------------

የመላሹ የትምህርት ደረጃ:------------------------------

የድርጅቱ የሰራር ባህሪ ና ከሌሎች ድርጅቶች ጋር ያለዉ መግባባት

ከታች ከተሰጡት ዝርዝሮች ዉስጥ 1-5 ካሉት X ምልክት ከ በመስጠት መልክቱ (1 ማለት ምንም የለም ሲሆን 5 ማለት በጣም ለ ማለት ነዉ)

ተ.ቁ	ዝርዝሮች	1	2	3	4	5
1	ሰራተኞቻችሁ ከሌሎች ደርጅት ሰራተኞች ለመማር ያላቸዉ ፈቃደኝነት					
2	ድርጅታችሁ ሌሎች ድርጅቶችን ለማስተማር ያለዉ ፈቃደኝነት					
3	ሰራተኞች ቴክኖሎጂዎችን ዲያመጡ ጥሩ የማበረታታት ባህል					
4	የሰራተኞችን ቴክኖሎጂ የመቀበል ብቃት ለማሳደግ ስልጠና የመስጠት ባህል					
5	ጥናትና ምርምር ለ ድርጅቱ ያልዉ ጥቅም					
6	ስልጠና ለድርጅቱ ያለዉ ጥቅም					
7	ለጥናትና ምርምር ና ለስልጠና ድርጅቱ የሚያወጣዉ ወጪ					
8	ቴክኒካል ዉቀቶችን ለማካፈል በድርጅቶች መካከል ያለዉ መተማመን					

9	ድርጅቱ ቴክኖሎጂን ለመዉሰድ ያለዉ ስትራቴጂ ና የተሰተዉ ትኩረት					
10	አዲስ ነገር ይዞ ለመምጣት በድርጅቶች መካከል ያለዉ ፉክክር					
11	ቴክኖሎጂን ለማስረፅ በንድ ቦታ ተሰብስቦ የመስራት ጠቀሜታ					
12	ቴክኖሎጂን ለመዉሰድ ና ለማስረፅ የባህል ወይም የካባቢ ተጽኖ					

የድርጅቱ ከድጋፍ ሰጪ ተቋማት ጋር ያለዉ አብሮ የመስራት ባህል

1. ድርጅቱ ከትምህርት ተቃማት ጋር አብሮ የመስራት ባህል አለዉ?

2. መልሶዎ አዎ ከሆነ እንዴት ነው አብሯችሁ የምትሰሩት

I. በፕሮግራም ስልጠና ይሰጡናል

II. ጥናትና ምርምር ይሰጡናል

III. ስራችን ለይ ስተያየት ይሰጡናል

IV. ስራችንን ይቆጣጠራሉ

V. ሌላ ካለ ግለፁ-------

3.ከሚከተሉት የትምህርት ተቃማት ዉስጥ በይበልጥ አብራቹ የሚሰራዉ የትኛዉ ነዉ?

I. ዩኒቨርሲቲ

II. ቴክኒክ ና ሙያ (ኢንዱስትሪ ኤክስቴንሽን)

III. ሌላ ካለ ግለፁ---------

4.ከሚከተሉት የምርምር እና ድጋፍ ሰጪ ተቀማት ዉስጥ በይበልጥ አብራቹ የሚሰራዉ የትኛዉ ነዉ?

I. ሌዘር ንዱስትሪ ዴቨሎፕመንት ንስቲቲዉት

II. ሌላ ካለ ግለፁ-------

5.የፋይናንስ ችግር ቴክኖሎጂን ለመዉሰድ ና ለመልመድ ከፍተኛ ተፅኖ አለዉ ብላችሁ ታስባላችሁ?

6.አዲስ ቴክኖሎጂ ለማምጣት ከ ፋይናንስ ተቃማት ድጋፍ የምታገኙበት ሁኔታ አለ?

7.የትኛዉ የፋይናንስ ተቃም ነዉ ማሽኖች ና ሌሎች ቴክኖሎጂዎች ለመግዛት በዋናነት የሚረዳቹ?

8. ከሚከተሉት ድጋፍ ሰጪ ተቀማት ለቴክኖሎጂ እድገታችሁ ለየትኛዉ የተሻለ ግምት ትሰጣላችሁ?

I. ለፋይናንስ ተቋማት
II. ለትምህርት ተቋማት
III. ለምርምር ተቋማት
IV. ለ ተቆጣጣሪ ተቋማት

ለድርጅቱ ሰራተኞች የቀረበ መጠይቅ

የሰራተኛዉ የትምህርት ደረጃ

I. ሃይስኩል ያጠናቀቀ
II. ኮሌጅ ዲፕሎማ

የሰራተኛዉ የስራ ልምድ ሁኔታ----------------------

የሰራተኛዉ ባህርይ እና የሰራር ባህል በተመለከተ የቀለቡ ጥያቄዎች

1.ከልሎች ጋር በትብብር መስራት የነበረን ወይም አዲስ ቴክኖሎጂን የመዉሰድ እና የመልመድ ሂደትን ያፋጥናል ብላችሁ ታስባላችሁ?

2.የሚከተሉትን ተግባራት በስራ ቦታችሁ ለቴክኖሎጂ መዉሰድ እና መስረጽ ያላቸዉን አስተዋጾ ደረጃ ስጧቸዉ (3 -በጣም አሰፈላጊ፣ 2- በመካከልኛዉ አሰፈላጊ 1 -በትንሹ አስፈላጊ)

I. የራስ ጥረት
II. ከስራ ሰአት ዉጪ በመገናኘት
III. በስልጠና

3.አዲስ ቴክኖሎጂን በቀላሉ ለመዉሰዱ እና ለመማር ይበልጥ ፈታኝ የሆነዉ የቱ ነዉ?

I. ዉስብስብ እና ለመረዳት ወይም ለመተግበር አስቸጋሪ ከሆነ
II. ከማምረት ሂደታችን ጋር ተግባቢ ካልሆነ
III. ጥቅሙ ወይም ዉጤቱ ግልጽ ካልሆነ
IV. ሌላ ካለ ግለፁ-----------

4.ከስራ ባልደረባችሁ ጋር ያላችሁን ግልፅነት እንዴት ትመዝኑታላችሁ

I. ከፍተኛ
II. መካከለኛ

III. ዝቅተኛ

IV. የለም

5.የስራ ባልደረባህን ከስራ ሰአት ዉጪ በምን ያክል ጊዜ ታገኛዋለህ?

I. ሁልቀን

II. አንዳንዴ

III. አልፎ አልፎ

IV. አንገናኝም

6.ለስራ ባልደረባህ ቴክኒካል ነገሮችን አና እዉቀቶችን የማ ስተላለፍ ባህልህን ወይም አመ ለካከትህን እንዴት ትመዝነዋለህ?

I. ከፍተኛ ነዉ

II. መካከለኛ ነዉ

III. ዝቅተኛ ነዉ

IV. የለኝም

7.ከስራ ሰአት ዉጪ ስትገናኙ ስለ ስራ ሁኔታ ታዎራላችሁ?

8.ለተራ ቁጥር 7 መልስህ አዎ ከሆነ በስራ ሰአት ከምትለዋወጡት እዉቀት ጋር እንዴት ታወዳድረዋለህ?

9.የማህበረሰብ ወይም የባህል እንቅፋቶች እዉቀቶችን እንዳትጋሩ እና እንዳትለዋወጡ የሚያደርጉበትን ሁኔታ እንዴት ታየዋለህ?