CHAPTER 5

SUMMARY AND CONCLUSION

Based on the results and finding following conclusions may be drawn.

5.1 Details of developed Stage Adoption model (SAM)

The developed Stage Adoption Model (SAM) consists of three parts i.e. primary adoption; secondary adoption along with assimilation; and consequences post adoption i.e. need for next generation purchase of robots. Primary adoption consists of four stages i.e. organization need; organizational knowledge; adoption decision at firm level; adoption decision at group. During primary adoption top managers play a critical role. Once the adoption decision is taken at firm level, it is mandatory to use robot in firm. Primary adoption leads to secondary adoption where individual adoption is important and is determined by managerial intervention, subjective norms and facilitating conditions. The process between secondary adoption and assimilation is iterative and has many levels. Assimilation process has six stages i.e. initiation; adoption; adaptation; acceptance; Routinization and infusion. Once the technology is started to be used in firm, three types of uses will emerge i.e. routine use, extended use and emergent use. These uses will motivate firm for further use of robots. On one hand positive feedback from routine use will motivate group for further use of robots in next activities while on the other hand positive feedback from extended use will motivate firm for use of robots further. In the proposed model, post adoption is also considered as extended use and emergent use of technology leading to purchase of next generation product.

SAM details and adoption process is shown in figure 5.1.
5.2 First order reflective measures

In all 26 first order reflective measurement models are developed by using 83 indicators. Out of which two attributes motivate the firm internally viz. “Workers demand for change of process” and “High cost of current process”. Also “Unavailability of technology (technology transfer, spare parts)” act as a barrier for adoption of automation at the firm level is found significant during expert opinion.

These 26 first order reflective measures were found reliable and pass the test of validity.
5.3 Second order formative measures

Totally 11 second order measurement models are developed which are formative in nature at second level where as reflective at first order. Results show 11 second order measurement models are default models in AMOS 7.0. All second order formative models are absolute fit except routinization stage as it is identified by two indicators i.e. one reflective and other as per position in Stages (Jarvis et al., 2003). All secondary models also fit for Comparative fit indices (CFI) except Routinization stage. Some of models are not fit as per RMSEA which may be due to less number of respondents as CFI and Root Mean Square Error of Approximation (RMSEA) improves with sample size (Sivo et al., 2006).

During organization need high correlation is found between internal and external motivators. This means that for any organization both internal and external motivators will create a need for adoption which is in line with (Statnikova, 2005). During adoption decision characteristics of adoption firm is more correlated with supplier marketing effort and perceived benefits of automation. This means that young and highly innovative firm which has high quality people will be influenced by supplier marketing effort. As positioning and risk reduction along with market support will help firm to adopt automation. Better communication and innovation development will be easy for adopting decision. Also young and innovative firm will adopt easily if automation improves productivity, quality, company image, competitiveness, safety of workers, working environment and also save time. High quality people will help in decision. During adoption decision supplier marketing effort are more correlated with perceived benefits of automation, which is in line with (Frambach, and Schillewaert, 2002). As they considered that supplier marketing effort will help in adoption of innovation. During adaptation stage of assimilation manager support is crucial which is helps in adaptation stage of assimilation is more and correlated with role of supplier; improvement in organization structure; improvement in technology application; and improvement in process benchmarking. This indicates that manager support is crucial for improvement is organization structure, technology application, process benchmarking. As during adaptation stage there is need for change in technology and firm which is similar to horizontal fit of new technology at capability level (Cabrera et al., 2001). Manager helps through their clear massage, retraining of workers, and site up gradation skills. During adaptation stage supplier will also play an important role in reduce state of knowledge gap; Improve compatibility of technology; and Improve trial-ability of technology. Manager’s support will help in
using these to improve in adaptation as manager can provide training, site up grading skills and clear massage. During adaptation stage of assimilation improvement in process benchmarking is more correlated with improvement in organizational structure; improvement in technology application; and improvement in employee enhancement. This means that if cost of use of machine in construction process is considered during design phase and Toyota Production System (TPS) is used will improve in employee enhancement as labour, middle managers concern and union concern about automation will be addressed properly. Also use of RFID systems, computers and computer integrated construction system will help in improving in process benchmarking. As cost of use of machine is concerned initially and computers are used greater interaction and coordination between workforces is possible through proper communication and education technique. During acceptance stage of assimilation collective belief and perception of individuals are more correlated with individual attributes. This indicates that individual attributes like young age, lower seniority, with less communication problem and similar values of users will increase collective belief and perception of individual. During need for purchase of next generation product extensive use and emergent use found more correlated. This finding is in line with (Hsieh, and Robert, 2006). As they considered that extensive use will have positive effect on emergent use. This may be because of better knowledge technology features provides good foundation to have better innovation.

5.4 Current status on use of automation for construction in India

Current status on use of automation for construction is observed based on activity wise and turnover wise of firms.

5.4.1 Based on activity use

Activity wise results on use of automation products in various activities show that all activities use all four types of automation products. It is found that use of remote and computer controlled machine is gradual and there is a trend towards use of robots more in Mumbai than Pune. Use of robots is more in Mumbai may be due to larger labour cost.
5.4.2 Based on turnover of firms

Results show that small firms with turnover 10-100Cr uses more robots and manually controlled machines. Medium sized firms with turnover 500-1000 Cr uses more computer controlled machine and tele-controlled machines. There is one more interesting finding that large firms with turnover 5000+ Cr use robots and tele-controlled machines. This shows that both larger firms and small firms use more of robots as compared to medium sized ones which are in line with (Carayannis, and Roy, 2000). As they observed that small firms are more technology driven and affected by technology push and pull. They are having technology for strategic choice. These firms can react fast due to small size. Larger firms are more market driven and affected by market push and pull. These firms have large budgets and can influence market practices and consumers. These firms can help in setting technical and market standards (Carayannis, and Roy, 2000). So small and large firms are the targets for robot manufacturing firms and penetrate adoption.

5.5 Strategies / drivers for adoption of robots for construction in India

Results show that all strategies had scored more than 6 on a seven point scale. This indicates the importance of all strategies in adoption as respondents are moderately agreed to strongly agree. Out of these strategies “Availability of spare parts of robots for easy maintenance”, is found important in expert opinion as the best found strategy. “Robots are available at rent”, is also found important during expert opinion and is ranked 5th.

CEO considers three top strategies i.e. “Availability of spare parts of robots for easy maintenance”; “Greater standardization of design and construction process”; and “More Large size project”. However five strategies i.e. “Increasing money to develop robots”, “More technical employees available”, “Greater cooperation with international contractor”, “More access to robots suppliers” and “Capital loan from government” scored less than 6. This shows that CEO consider that increasing money, cooperation with international contractor, access to robot supplier and capital loan from government has less effect on increasing adoption of robots in construction.

Project Managers considers three top strategies as: “Availability of spare parts of robots for easy maintenance”; “Greater awareness of robots within the
construction industry”; and “Greater standardization of design and construction process”, as important. However three strategies i.e. “Greater cooperation with international contractor”, “Capital loan from government” and “Relaxation in laws and policies of Government” score less than 6. This means that as per project manager greater cooperation with international contractor, capital loan given by government and relaxation of laws and policies by government has little effect in adoption of robots in construction.

Users consider top three top strategies as: “Availability of High level construction automation /Robotics institute”; “More Large size project”; and “Greater awareness of robots within the construction industry”.

Marketing firms which target robot industry, have to consider helping in standardization of design and construction process and also making available spare parts of robots for easy maintenance for increasing adoption of robots. Also adopting firms, which are interested in adoption must consider proper training and increase awareness of robots within construction industry.

5.6 Adopting high technology automation products (robots) in its various stages

During adoption of Robots in construction, pressure for change in firms comes from organizational needs (pull) and technological innovation (push) or both (Cooper, & Zmud, 1990; Ivkovic, and Nehlin, 2007). Hence factors which influence organizational need and technological innovation will drive the adoption process initially. (Carayannis, and Roy, 2000) also observed pull and push scenario in which pull focuses on solving a problem by providing a technical answer to a market need and push focuses on identifying a market need to accommodate an existing technical solution. Push and pull can be defined from either a technology or market point of view as: technology push; technology pull; market pull; market push (Carayannis, and Roy, 2000).

Once adoption decision is taken by a firm, robotics technology is introduced to the adopting firm. As per (Cabrera et al., 2001) whenever a new technology is introduced for implementation it will affect the other sub systems of organization. Hence either technology is to be designed to fit in organizational structure or
organization structure has to be changed to fit demands of new technology. Technology has to fit vertical and horizontal levels (Cabrera et al., 2001). This is similar to technology pull condition and also market push situation which will influence implementation. Forces which drive adoption are shown as in Figure 5.2.

![Figure 5.2 Various forces which drive Adoption process](source)

After acceptance the users start using the technology for their tasks. If they find that new technology is easy to use they use it regularly. Regular use helps in extended use of technology. If users find more satisfaction and enjoyment by using technology they use it more innovatively. This will lead in demand for improvement in technology features, creating a need for updating and thus leads to next generation. This need of technology leads to bottom up secondary adoption situation. This bottom up secondary adoption force a change in the form of organizational need (pull) for next generation product. This will continue the adoption process until full cognitive robots are adopted. This is in line with findings/ observation of (Carayannis, PhD thesis on Adopting High Technology Automation Products to Infrastructure Construction Industry with Special Preference to Pune and Mumbai, 2013).
and Roy, 2000). They claim that market push and technology pull leads to radical improvement and sets standard for technology. Figure 5.3 shows the changes in adopting firm during adoption process.

Innovative firms want to modify high technology products in such a way that R&D costs will be recovered properly through life cycle of product. In this model various stages of high technology automation are considered. S1-S4 are the four stages of high technology products i.e. manually controlled machine, tele-controlled machine, computer controlled machine and cognitive robots respectively. Stage gate during new product development acts as decision points and represented by

Figure 5.3 Changes in adopting firm need during for next level robots during adoption process
Source : (Jain, and Phadtare, 2013)
diamond shape. They serve as quality control checkpoint, providing a funnelling of projects, pointing towards a path forward (Cooper, and Edgett, 2006). This study considers G1 - G3 as three gates during product development. G1 is stage gate between manually controlled machine and tele-controlled machine. G2 is stage gate between tele-controlled and computer controlled machine. G3 is stage gate between computer controlled machine and cognitive robots. These technology stage gates are opaque in nature i.e. technology team can see at initial gate. Technology team can see other gates also once they will pass through changes in first stage (Ajamian, and Koen, 2003). This is shown in Figure 5.4.

Figure 5.4 Technology changes in supplier firm’s adoption process Source: (Jain, and Phadtare, 2013)

Hence robots can be adopted for four levels i.e. manually controlled machine; tele-controlled machine; computer controlled machine; and cognitive robots.
5.7 Usefulness of study

Current study helps adopting firm to identify various stages of adoption process. Firms will get a proper view of various factors which influences these stages. For any adopting firm, internal and external motivation is very important to identify their problems which can be solved through technology.

Supplier firms and manufacturing firms, who targets robots as product, can be helped by this study. This study helps them to identify the need of customer properly. As in study various stages were considered for automation products, supplier firms can develop the automation products in stages. Their technical team will observe the outcome of development through close communication with adopting firms. This will help them to modify and change their product which suites the need of customer.

This study helps beneficiaries also as it provide them good quality products i.e. infrastructure construction works in time, cost.

5.8 Contribution to Knowledge / Practice

There are following areas in which this study contributes to literature. Contribution to knowledge:

1. Developed structural models i.e. second order measurement models for various stages of adoption
2. Integrated TAG model and post adoption i.e. purchase of next generation products

Contribution to practice:

1. “Unavailability of technology (technology transfer, spare parts)” as a barrier for adoption of robots at firm level was developed.
2. Strategy i.e. “Availability of spare parts of robots for easy maintenance”, and “Robots are available at rent”, found significant.

Contribution to both i.e. knowledge and practice:

1. Identified “Workers demand for change of process” and “high cost of current process” as two indicators for internal motivation.
5.9 Limitation and future scope of study

Model considers various factors for each stage of adoption process. However it does not explain the adoption reasons for market pull and technology push and market push and technology pull during primary and secondary adoption respectively in detail. Also changes at every technology stage gate are required to be considered in detail.

As study included Pune and Mumbai as geographical region, the model can be tested all over India. Further model can be tested for other sectors of construction like real estate also.