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IT Adoption Model Development for Improving Supply Chain Performance of Enterprises in Developing Countries: A Case of Ethiopian Manufacturing

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Abstract

Information technology (IT) is one of the biggest enablers in the contemporary SCM**.** However, the roles of IT adoption models on the supply chain performance of manufacturing enterprises in developing countries were not adequately investigated in the past. This study investigates the effects of IT models on supply chain (SC) performance in manufacturing enterprises of developing counties. It starts by measuring the level of understanding about the roles of IT adoption models on SC performance from survey enterprises. Further, depending upon identified critical success factors and barriers to IT adoption from the literature and empirical survey, a new IT adoption model is proposed. A cross-sectional survey was conducted by taking 438 samples from a population of 2,758 Ethiopian medium and large-scale manufacturing firms. The findings from the survey generally indicated significant positive relationships between IT practice levels and SC performances, although they faced different challenges to implement IT adoption models.

Keywords: Supply chain performance, IT adoption model, critical success factors, manufacturing enterprises

1. Introduction

Today, organizations are competing in global and domestic businesses, striving for winning market domains with quality product delivery, reliable customer service, and accurate information flow to the partners using the right supply chain management (SCM) strategies. Information technology (IT) is one of the biggest enablers of the modern SCM. According to the Global SC Forum, the term SCM is defined as ‘‘the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders’’ (Lambert, 2004). Today the new source of competition lies outside the walls of organizations and is determined by how effectively companies link their operations with their SC partners such as suppliers, distributors, wholesalers, retailers, and end customers. SCM offers a management philosophy to manage activities and integrate with downstream and upstream partners as well as firms’ internal SC. Thus, managing the SC in this business environment has a major impact on the performance of all parties involved in the chain (Refu, 2016). Better information exchange between SC partners is perhaps the key advantage of integration. Levary (2000) reviewed some of the benefits of electronic-based SC integration such as minimizing the bullwhip effect; improving the efficiency of activities; reducing inventories and cycle times, and improving the quality of products and services along the supply chain.

Gustin et al., (1995) showed that IT innovation provides the capabilities to transfer more accurate and up-to-date information resulting in better visibility of demand and inventory throughout the supply chain, effective management of strategic alliances, extensive data management capabilities, advanced inter-organizational information systems, and generally successful SCM. Hence, the upstream through downstream integration in the supply chain network is the basic requirement to fulfill the objectives of SCM. The IT-enabled SCM can easily manage the flow of information with key business processes, materials, and money within and outside the networks and contributes to firm profits by improving quality and by reducing coordination costs and transaction risks (Mabert et al.,2001; Sanders and Premus, 2002). According to Ejiaku (2014), IT adoption propels the economies of nations to greater productivity and creates jobs. The modern global economy is built on IT and telecommunication infrastructure, which serves as a platform for national and global development. Hence, IT has great potential to improve business operations; education, technology, and economic growth that could help developing economies alleviate poverty and meet local and national needs. Dametew and Ebinger (2017) indicated that the technological capability of local industries to invent, adapt, modify, improve and use of a given innovative technology is very poor in manufacturing firms of developing nations. The researchers stated the reasons for poor technological innovations such as improper innovation and technology transfer framework, non-collaborative operating environment between foreign and local industries, and weak national technology policies. In addition, they suggested adopting flexible innovative and sustainable technological innovation systems to manufacturing industries used as a vehicle for improving the performance and competitiveness of the firms.

Although the importance of IT adoption frameworks for efficient SCM was widely acknowledged in previous studies, the role of IT adoption models on the SC performances of manufacturing enterprises in the developing world was not well studied in previous research. The understanding levels regarding the importance of IT adoption models for improving SC performances were not adequately studied in such kinds of enterprises. Mostly IT adoption-related studies in developing nations focused on identifying critical success factors (CSFs) and barriers to implementing IT adoption (Dametew and Ebinger, 2017; Lin, 2014; Wong et al., 2020). In addition, the proposal of IT adoption frameworks for manufacturing firms in developing nations using specific survey results (such as CSFS and barriers) and the current literature was not studied. That means theoretical IT adoption models were not developed based on the findings from manufacturing firms in developing nations. Therefore, the purpose of this study is to bridge this study gap.

This study has a significant contribution to the current knowledge. It investigates the practices of IT adoption models and the level of understanding about the importance of such models on SC performances. Further, it identifies the barriers and CSFs to implement IT adoption models for surveyed enterprises. Finally, it proposes a model of IT adoption for SCM for manufacturing enterprises of developing nations by integrating survey results and the current theoretical perspectives. The study can provide guidance for surveyed firms to improve their SC performances by applying the proposed IT adoption model. Moreover, it can give insight to policymakers, researchers, and other stakeholders that have an interest to undertake further study in IT adoption model development in other industrial sectors.

This paper is organized into six sections. Section 2 reviews basic concepts of SC performances, the roles of IT on SC performances, CSFs, and challenges to adopt IT model and find literature gaps from related studies. The data collection and analysis methods are explained in Section 3. Section 4 presents the empirical findings regarding the level of understanding of the significance/effects of IT adoption levels on SC performances. A new IT adoption model is proposed in Section 5, based on empirical and theoretical findings. Finally, conclusions are drawn depending on the results in Section 6.

2. Literature review

2.1 Supply chain performance

Supply chain management (SCM) is an effort by suppliers to make efficient and economical supply chains and an IT has a significant effect to achieve this (Bolmole, 2000). SCM has been defined in many ways by different SC researchers in the current literature as reviewed by Stock and Boyer (2009) and LeMay et al. (2017). Currently, the most comprehensive definition is provided by the Council of Supply Chain Management Professionals (CSCMP). According to the CSCMP, it encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities in coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers (Stock and Boyer, 2009; LeMay et al., 2017). Based on this definition, supply chain performance (SCP) is a crucial source of sustainable development in contemporary industries by considering multiple performance measures pertaining to SC members (Banomyong and Supatn, 2011). Various sources of literature have proposed a set of new measures and frameworks to respond to the current needs for SCP measurement (see reviewed frameworks in Shepherd and Günter (2006) and Balfaqih et al. (2016)). However, the Supply Chain Council (SCC) developed the Supply Chain Operations Reference (SCOR) model with the assistance of 70 of the world's leading manufacturing companies (https://scm.ncsu.edu). As reviewed by Balfaqih et al. (2016), the SCOR model uses several performance metrics with five attributes such as reliability, responsiveness, flexibility, cost, and asset. The recent version of this model, SCOR Version 12.0, is presented in the American Production and Inventory Control Society (APICS) as shown in Table 1.

Table 1: SCOR Performance attributes and strategies (APICS, 2017)

Perspective	Attribute	Strategy
Customer	Reliability	Consistently getting the orders right, the product meets quality requirements
	Responsiveness	The consistent speed of providing products/ services to customers
	Agility	The ability to respond to changes in the market (external influences)
Internal process	Cost	The cost associated with managing and operating the supply chain
	Assets	The effectiveness in managing the supply chain's assets in support of fulfillment

2.2 Related studies of IT adoption models

The reviews in the current literature focused on the comparison of IT adoption models at the individual and firm levels. Oliveira and Martins (2011), Williams et al. (2015), and Francisco and Swanson (2018) stated that the popular theories at the individual level are the Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), combined TPB/TAM, Model of Personal Computer Utilization (MPCU), Social Cognitive Theory (SCT), and Motivational Model (MM), and Unified Theory of Acceptance and Use of Technology (UTAUT). The theories of IT adoption models at the firm level are two prominent models: Diffusion of Innovation Theory (DIT), and the Technology, Organization, and Environment (TOE) framework. Several empirical studies were conducted to determine the relationships between IT and the performance of SC, the role of SC technology and firms' performance, adopting new technologies for SCM, strategies for successful IT adoption, determinants of IT adoption, and benefits of IT in SCM, and challenges and Barriers for implementing IT adoption models.

The TRA is used to predict an individual's intention and behavior to accept technology depending on existing beliefs and attitudes (Ajzen and Fishbein, 1980). The TAM is based on the TRA and was originally proposed by Davis (1989) and contains two core elements that end users to use and accept IT adoption models, namely perceived ease of use (PEOU) and perceived usefulness (PU). Other essential elements including external variables, attitude, behavioral intention, and actual use, were synthesized by Legris et al. (2003).

The TPB was developed by Ajzen (1991) to predict human behaviors (psychological factors) based on attitudes, subjective norms, and perceived behavior for technology acceptance. The combined TPB/TAM incorporates two factors such as subjective norm and perceived behavioral control) to the original TAM to provide more emphasis on important determinants of technology usage and acceptance (Taylor and Todd, 1995). The MPCU is highly concerned with predicting a technology usage behavior rather than intentions to use it (Thompson, 1991). The SCT addresses environmental influences and personal factors that are equally significant in determining behavior for technology usage (Bandura, 1986). The MM focuses on the core constructs of extrinsic and intrinsic motivation theories for technology acceptance and usage (Davis et al., 1992). According to Rogers (1995), DIT is a theory of how, why, and at what rate new ideas and technology spread through cultures, operating at the individual and firm levels. Based on DIT at the firm level, innovativeness is related to independent variables such as individual (leader) characteristics, internal organizational structural characteristics, and external characteristics of the organization.

The UTAUT suggests that four core constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of behavioral intention and ultimately behavior and that these constructs are in turn moderated by gender, age, experience, and voluntariness of use (Venkatesh et al., 2003). It was developed by reviewing and integrating of eight dominant theories and models stated above (Williams et al., 2015; Francisco and Swanson, 2018). The application of the UTAUT in e-logistics was reviewed by Ayaz and Yanartas (2020) and its wide applications were reviewed by Williams et al. (2015). Tornatzky and Fleischer (1990) proposed the TOE framework to identify three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation: technological context, organizational context, and environmental context. The TOE provides a more comprehensive view of new technology adoption by integrating both human and non-human factors as compared with TAM, DIT, and UTAUT frameworks (Mohtaramzadeh et al., 2018; Awa et al., 2017).

The adoption ladder model was originally adapted from a Cisco-led information age partnership study on e-commerce in small businesses (Martin and Matlay, 2001). This adoption ladder approach was used by the UK government's Department of Trade and Industry (DTI) for a better understanding of the adoption of ICT by existing small firms (Parida et al., 2010). The main idea behind this model is that a small firm approaches ICT adoption through a series of stages, in a well-planned and sequential manner.

In addition to the reviewed conceptual (theoretical) frameworks, several empirical studies were conducted regarding the CSFs and challenges for IT adoption, and relationships between IT adoption models and SC performance. According to the review by Ngai et al. (2008), the most frequently cited CSFs for implementing IT adoption frameworks are top management support and effective communications at all levels of an organization. Raut et al. (2017) stated that organizational readiness (technological and financial readiness) is an important factor for IT adoption. In addition, the researchers identified other factors such as employee knowledge and training, government support in IT infrastructure, firm size, and firm age, strategic planning for IT adoption, and good innovation culture. According to a review by Hollenstein (2004), challenges or barriers in IT adoption were identified as investment costs, unfavorable financial conditions, human capital restrictions, lack of managerial awareness of the benefits of IT, and insufficient IT-oriented training. The 'security' assurance from the service provider is a key driver for IT adoptions. Raut et al. (2017) reviewed security issues in IT adoption as not only about accountability, authorization, and authenticity but also concerned with business continuity, disaster recovery, and data protection. Patterson et al. (2003) developed a model of the key factors influencing the adoption of SC technology such as firm size, organizational structure, integration of SC strategy with overall corporate strategy, financial performance, SC partner pressure, transaction climate, and environmental uncertainty.

Lin and Lin (2008) proposed an IT adoption model for Taiwanese firms to determine the determinants of e-business diffusion theory and the technology–organization–environment (TOE) framework using a structural equation modeling (SEM) approach. Lin (2014) investigated the determinants of e-SCM adoption across non-adopters and adopters based on the TOE framework. Wong et al. (2020) investigated the effects of relative advantage, complexity, upper management support, cost, market dynamics, competitive pressure, and regulatory support on blockchain adoption for operations and SCM in Malaysian SMEs by adopting the TOE framework.

2.3 Literature summary and research gap

The current literature on theoretical IT adoption models focused on three categories. They are individual-oriented, firm-oriented, and adoption ladder models. The UTAUT is highly recognized at the individual level (Williams et al. 2015; Ayaz and Yanartas, 2020) because it was proposed by reviewing and integrating eight dominant theories (Williams et al., 2015; Francisco and Swanson, 2018). At the firm level, the TOE framework is widely applied as it provides a more comprehensive view of new technology adoption by integrating both human and non-human factors (Mohtaramzadeh et al., 2018; Awa et al., 2017). The ladder model provides a better understanding of ICT adoptions by existing firms through a series of well-planned stages (Parida et al., 2010). These three categories of theoretical models were developed to address the problems of enterprises in the developed world.

In addition, the empirical studies conducted in the developing world concerned with the CSFs and challenges for IT adoption (Dametew and Ebinger, 2017; Lin, 2014; Wong et al., 2020) based on the existing theories that were proposed to articulate the IT adoption problems of firms in developed nations. This implies that the current literature lacks to investigate the level of understanding of the significance/effects of IT adoption models on SC performances of manufacturing enterprises in developing countries. This helps to develop a theoretical IT adoption model for manufacturing firms in developing nations based on the findings of their specific problems. This paper aims to bridge this gap. It is intended to propose a new theoretical model for IT adoption depending on the empirical findings from the surveyed manufacturing firms in Ethiopia and well-established theories from the current literature.

3. Research methodology

Both qualitative and quantitative approaches were applied in this study. The qualitative approach was concerned with the subjective assessment of the attitudes, opinions, and behavior of respondents. The qualitative approach was employed to gather respondents' perceptions towards IT roles in SCM performances and their suggestions on what to be considered during the IT adoption process. The quantitative approach was used to collect numeric data from participants, analyze these numbers using statistics, and conduct the inquiry in an unbiased, objective manner. This approach was applied for the study to analyze responses to Likert scale questions. Both primary and secondary types of data were collected from different sources. Primary data were collected from sample enterprises by using a self-administered questionnaire that was designed to collect responses for qualitative and quantitative analysis. Primary data were gathered via survey questionnaires and interviews with different-level managers as well as owners of manufacturing enterprises. Secondary data was collected from published or unpublished articles, academic journals, dissertations, thesis, conference proceedings, government reports, and books by using online databases and library services.

3.1 Sampling method

For this study, the researchers used probability sampling particularly the stratified sampling technique since the population is large (2760) and heterogeneous. In Ethiopia, there are about 2760 registered MLSM firms both private and public-owned (CSA, 2017). Eight manufacturing sectors were considered as strata based on their similarity. Then the samples were proportionally selected from each stratum by a simple random sampling method. According to Cochran (1977), a formula (sampling distribution of proportion) for calculating sample size when population size is finite:

$$n = \frac{Nz^2pq}{e^2(N-1)+z^2pq}$$

Where:

N= the population size

n = the sample size

z = the selected critical value of desired confidence level (from the normal distribution table)

p = the estimated variability proportion of an attribute measure in the population[1]

q= 1- p

e = the desired level of precision (acceptable sample error)

[1] Because a proportion of 0.5 indicates the maximum variability (heterogeneousness) in a population, it is often used in determining a more conservative sample size

According to this method, researchers commonly use z= 1.96 for a 95% confidence level, e=0.05 as a desired level of precision, and $p=q$ =0.5 conservatively.

The sample size n can be determined as

$$n = \frac{(2760)(1.96)^2(0.5)(0.5)}{(0.05)^2(2760-1)+(1.96)^2(0.5)(0.5)} = 337 \text{ enteprises}$$

Assuming 75 % of the response rate from the researchers' experience, the sample size was revised as:

$$n = \frac{337}{0.75} = 450 \text{ enterprises}$$

After the determination of this sample size, 450 questionnaires were proportionally distributed to the corresponding enterprises in eight manufacturing subsectors. However, the return rate was 438 (77%) enterprises. The distribution of the response from the eight subsectors is shown in Table 2.

Table 2: Respondent size by stratification method

SN	Strata/sub-sector	Target population	Respondent size
1	Chemical and Chemical Products	242	35
2	Food and Beverage Products	540	96
3	Leather and Leather Products	341	44
4	Metal and Engineering Products	228	22
5	Other Non-Metallic Mineral Products	309	54
6	Rubber and Plastic Products	343	57
7	Textiles and Apparel Products	249	38
8	Wood, Paper and Pulp Products	508	92
	Total	2760	438

The distribution of surveyed enterprises by the category of suppliers and customers, and employees is presented in Figures 1 and 2 respectively. In addition, Figure 3 shows the distribution of respondents by their job title.

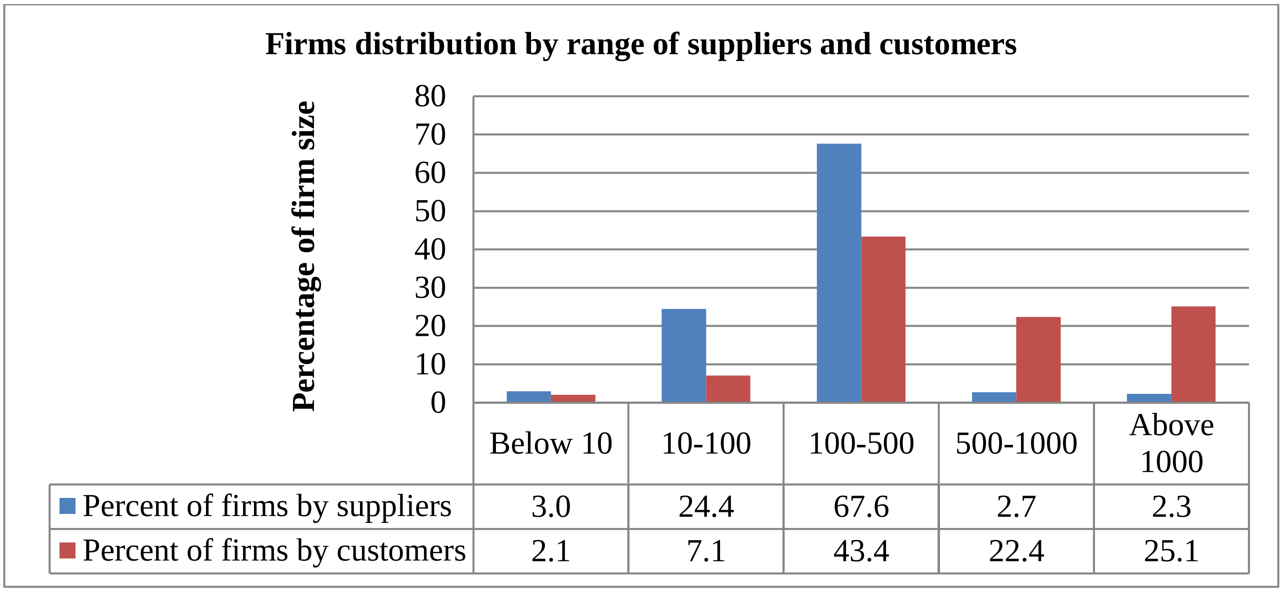

Figure 1: Number of suppliers and customers of the enterprises

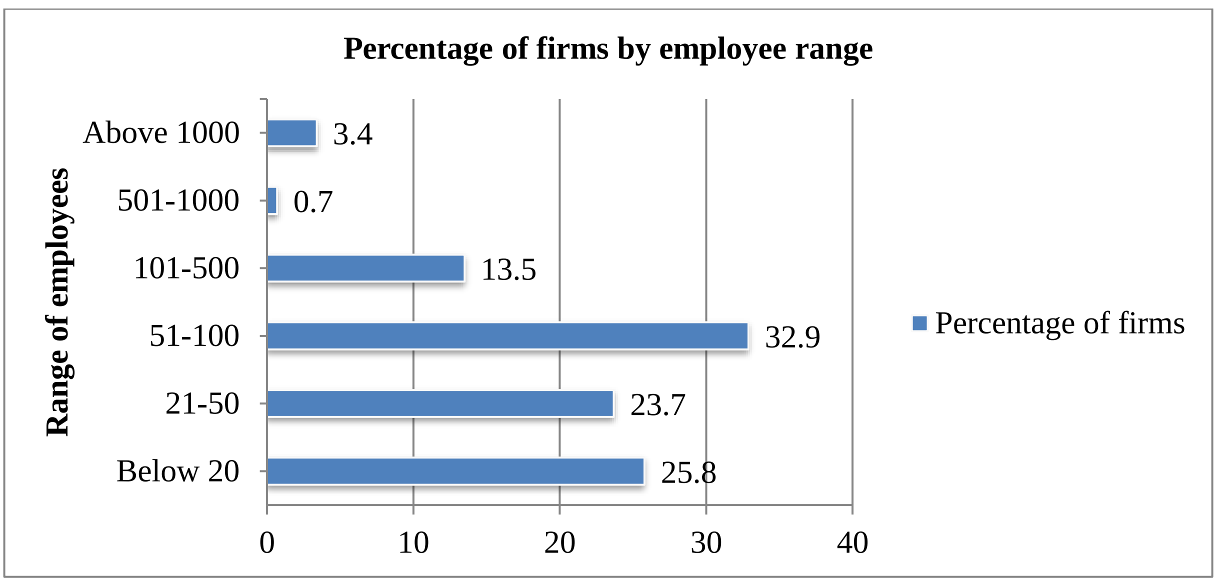

Figure 2: Percentage of firms by employee size

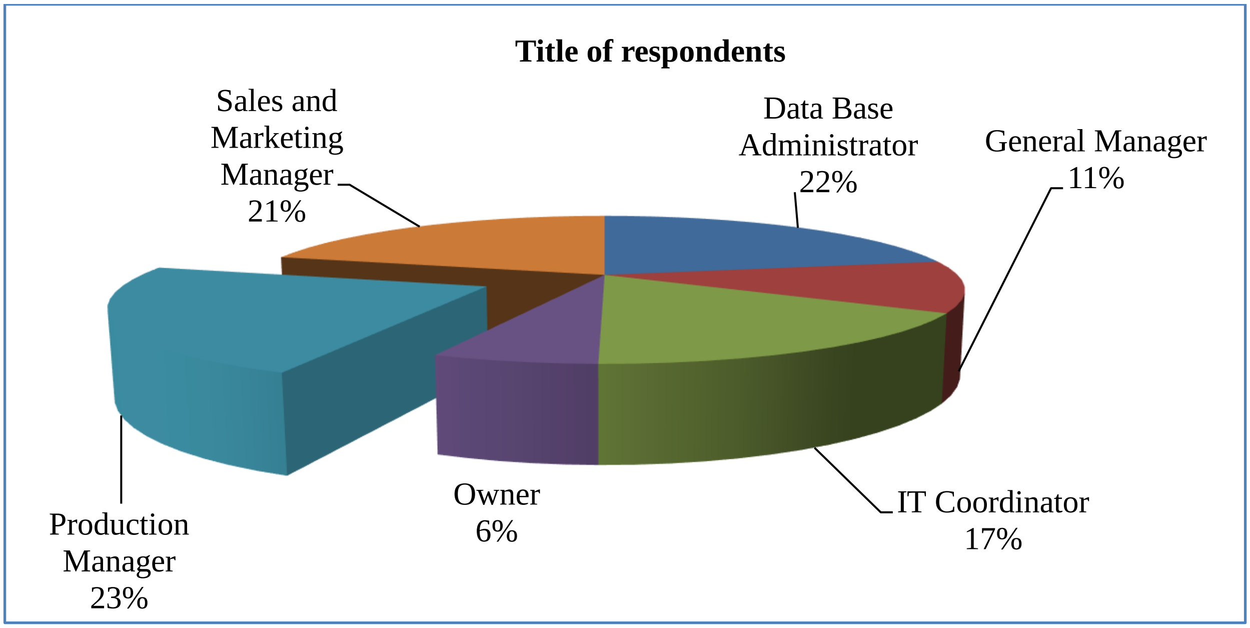

Figure 3: Respondents distribution by their title

3.2 Data collection method

Data were gathered through different methods particularly using survey questionnaires, interviews, and document investigations.

Questionnaire survey: Researchers used questionnaire surveys involving major close-ended and a few open-ended questions. The close-ended questions were designed to address groups of people simultaneously since they are less costly and less time-consuming. Open-ended questions were used to give freedom of describing personal opinions without external bias. Consequently, some questions were provided with blanks for personal opinions. Hence, standard questionnaires compiled by researchers with due attention, have been distributed to sampled firms physically as well as by using e-mail. The questionnaire developed was adopted from the Likert-type scale method. The Likert-type scale method used a range of responses: 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree', and 'Strongly Agree', with a numeric value of 1-5, respectively. The usage of this particular scaling method ensures that the research study illustrates the ability to assess the responses and measure the responses quantifiably. The core instrument for primary data collection was the questionnaire survey in this study. It was designed to measure the IT adoption status, CSFs, barriers to implementing IT adoption models, roles of IT on SCM, and SC performance in surveyed MLSM enterprises using the stated Likert scale.

Interviews: Direct interview was carried out with selected enterprises. The number of interviewees was 15, which were deliberately selected from different level managers and the interview was conducted through a face-to-face approach. The aim of this interview was to get the detailed information regarding IT adoption status, opportunities, and challenges to adopt IT among manufacturing enterprises in Ethiopia and to determine what type of IT adoption model/framework should be proposed and how the proposed model should be implemented for these companies.

3.3 Data analysis

After the data was collected, descriptive statistical techniques were employed to analyze the collected. It was analyzed by using Statistical Packages for Social Science (SPSS) version 21, and a Microsoft Excel spreadsheet. Finally, the proposed conceptual model or framework to adopt IT for manufacturing enterprises of developing nations was developed using the results obtained through analysis of fieldwork and a thorough review of previous studies.

3.4 Validity and reliability test

A validity test was performed to find if the instruments appropriately measure the variable. It was performed using Pearson correlation with a significance level of 5% (α = 5%). After the validity test, a reliability test was performed to ensure the consistency of the responses (Hair et al., 2010). The validity test result in Table 3 for barriers and CSFs to IT adoption, functional roles of IT adoption in SC and SC performance shows good relation even though some results indicate low values (0.502, 0.692, and 0.631) for governmental and environmental barriers, and asset management SC performance respectively. Hence, all the instruments of variables can be used in the next analysis. The reliability test result in Table 4 shows that all the instruments used are reliable with Cronbach's alpha coefficient greater than 0.8. This indicates that the instrument is adequate to measure internal consistency.

Table 3: Validity test result

No.	Instrument	Pearson Correlations [c]
	Barriers	
1.	Individual	0.817**
2.	Organizational	0.785**
3.	Technological	0.870**
4.	Governmental	0.502**
5.	Environmental	0.692**
	CSFs	
1.	Individual	0.867**
2.	Organizational	0.940**
3.	Technological	0.815**
4.	Governmental	0.901**
5.	Environmental	0.929**
	Functional roles	
1.	Transaction execution	0.726**
2.	Collaboration and coordination	0.806**
3.	Decision support	0.778**
	SC performance	
1.	Reliability	0.840**
2.	Responsiveness	0.844**
3.	Flexibility	0.882**
4.	Cost	0.801**
5.	Asset management	0.631**

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4: Reliability test result

No.	Variables	Cronbach's	No. of items
1.	Barriers	0.894	7
2.	CSFs	0.945	7
3.	Functional roles	0.910	15
4.	SC performance	0.944	19

4. Empirical results and discussions

This section examines the relationship between the practices of IT adoption models and SC performance to develop a conceptual model for IT adoption with the help of empirical findings of sampled manufacturing enterprises.

4.1 IT adoption status in survey firms

The bar chart (Figure 4) illustrates the number of MLSM enterprises adopting different IT tools that are perceived as enablers of effective and efficient SCM performance. The IT tools that are mostly adopted from the surveyed companies are the Internet, Intranet, bar code and scanner, computer-aided design (CAD), product data management (PDM), Automated Quality Control (AQC), and warehouse management system (WMS) and data warehouse and data mining (DW & DM). Particularly, the users of the Internet in business practices were very large (accounting for 288 firms), which shows that the manufacturing industries especially MLSM firms have been shifting the paradigm towards e-business. There is a greater preference for using the Internet as an enabler to receive and put orders, deliver products, communicate with suppliers and customers and advertise electronically using several websites.

The Intranet was shown the second largest enabler of SCM for MLSM firms and was implemented by 192 firms. An intranet is a network of computers, similar to the Internet, only accessed by staff within a particular company or organization. This helps many departments in a particular company to exchange information internally. Bar code scanner was one of the transaction execution tools being used by 80 firms among surveyed MLSM firms. Its function extends from identifying product specifications to improving customer service time. Among the surveyed firms, only 33 firms developed their own World Wide Web (WWW) page, 40 firms use electronic procurement (e-procurement), 30 firms have transportation management systems (TMS), 38 firms have computer-aided manufacturing (CAM), and 20 firms have Digital Signatures. Only a few companies implemented some sophisticated supply chain technologies such as enterprise resource planning (ERP), electronic data interchange (EDI), radio frequency identification (RFID), SCM, and even most surveyed firms surveyed have not developed a website for their company.

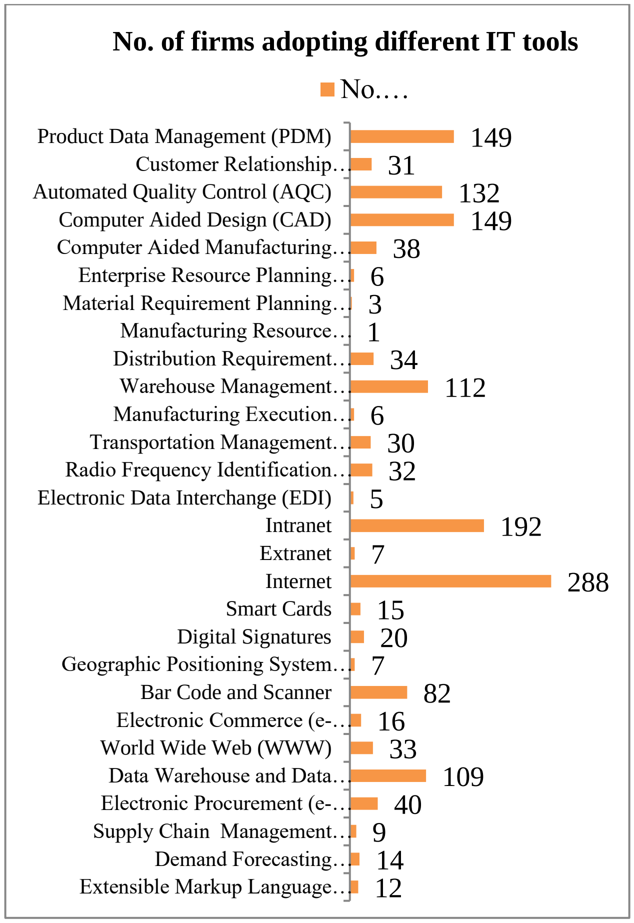

Figure 4: Different IT tools adoption status among survey firms

In addition, Table 5 shows the statistical mean results from surveyed enterprises about the level of IT implementation in their organizational departments. Firms responded to questionnaire prepared in five Likert-scale (5 =Very Highly, 4 =Highly, 3 =Moderately, 2 =Lowly, & 1=Very Lowly).

Table 5: Descriptive statistics of IT adoption in different departments

Departments	**Mean**	**Std. Deviation**
Human resource (HR)	3.05	0.787
Procurement and supply chain	2.96	1.037
Production	3.34	0.786
Sales and marketing	3.03	1.083
Finance and accounting	3.29	0.835
Research & Development (R&D)	2.64	1.047
Quality control	3.00	1.068

The result scored by firms was almost moderate (3 scores) and above in human resource (HR), production, sales and marketing, finance and accounting, and quality control departments. Only procurement and supply chain and R&D departments responded between lowly (2) and moderately (3) application of IT, scoring mean values of 2.96 and 2.64 respectively. These two departments are even new concepts to many firms so they need due consideration since their effectiveness would have a high impact on organizational performance. Generally, it shows that the IT system is not adequately implemented in all departments.

4.2 Critical success factors and barriers of IT adoption

Table 6 describes the statistical results of different CSFs for IT adoption in MLSM firms. All the mean values were scored above moderate (3) value from a 5-Likert scale. Specifically, good innovation culture, open communication system, availability of finance, top management support and involvement, and clear and systematic direction in planning were responded with the score of 3.18, 3.14, 3.39, 3.28, and 3.35 respectively. The remaining such as employee training and automated production and control system responded with slightly lesser values scoring 3.12 and 3.03 respectively. The result implies that all described CSFs moderately affect the IT adoption process. These results support literature reviews about different kinds of CSFs affecting the acceptance of IT in organizations mentioned by Raut et al. (2017) and Ngai et al. (2008). The standard deviation score shows almost nearly similar values implying the consistency of answers from respondents except for one larger value for automated production and control systems.

Table 6: Descriptive statistics of CSFs to adopt IT

CSFs	**Mean**	**Std. Deviation**
Good innovation culture	3.18	0.654
Open communication system	3.41	0.601
Availability of finance	3.39	0.923
Top management support and involvement	3.29	0.673
Employee training and education	3.12	0.597
Clear and systematic direction in planning	3.35	0.737
Automated production and control system	3.03	1.085

Table 7: Descriptive statistics of barriers to adopt IT

Barriers	**Mean**	**Std. Deviation**
Resistance to change	3.25	0.755
Lack of government support	3.19	0.855
Lack of budget	3.53	1.086
Lack of strategic planning perspective	3.50	1.097
Lack of skilled labor	3.36	0.881
High cost of technology	3.81	0.724
IT security threat	2.93	0.573

In Table 7, all mean responses for barriers to IT adoption lie between high (4) and moderate (3) values except a single response of 2.93 for IT security threats. Resistance to change, lack of government support, lack of budget, lack of strategic planning perspective, lack of skilled labor, and high cost of technology were IT adoption barriers with the mean response score of 3.25, 3.19, 3.53, 3.50, 3.36, and 3.81 respectively. A few of them affect the IT adoption process to a higher degree than others, for example, the cost of technology (mean = 3.81). Indeed, some sophisticated SC technologies such as ERP, MRP I and II, RFID, etc., require millions of dollars for adoption and implementation cost.

4.3 Roles of IT adoption models on SCM

This section presents the level of understanding of the respondent enterprises regarding the roles of IT adoption models on specific SC performances. Table 8 presents the basic statistical analyses applied in this study. The researchers used a five Likert scale score (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) to rate the functional roles of IT adoption models in SCM for surveyed manufacturing enterprises. Three business functional areas were analyzed in which most importantly IT tools could be applied to improve SC performance. These were transaction execution, collaboration and coordination, and decision support.

All survey companies agreed with approximately "Agree" scores on the roles of IT adoption models on SC transactions with mean scores of 3.91, 3.83, 3.84, and 4.05 for procurement, sales, order management, and customer service respectively. The roles of IT adoption frameworks in both intra-organization and inter-organizational collaboration and coordination were scored above 3.75 and the mean scores imply the "Agree" degree of agreement. The mean scores for each question under the decision support category were relatively lower as compared to the scores of other functional areas. They were responded as sourcing decision (3.67), supplier selection (3.91), transportation decision (3.88), and network design support (3.77).

Table 8: Descriptive statistics of functional roles of IT adoption models on SCM

Functional roles	Mean	Std. Deviation
Transaction execution		
IT enables procurement transaction	3.91	0.707
IT assists sales transaction	3.83	0.749
IT enhances order management system	3.84	0.840
IT improves customer service	4.05	0.808
Collaboration and coordination		
i. **Intra-organizational collaboration and coordination**		
IT increases interdepartmental collaborative planning	4.04	0.731
IT improves internal collaborative production system	4.02	0.756
IT improves interdepartmental integration	4.09	0.672
ii. Collaboration and coordination along the supply chain		
IT increases collaborative planning with suppliers and customers	3.76	0.648
IT increases collaborative forecasting along SC	3.78	0.765
IT increases collaborative replenishment	3.75	0.764

IT improves SC integration and coordination	3.86	0.741
Decision Support		
IT enhances sourcing decision	3.67	0.754
IT improves supplier selection	3.91	0.903
IT improves transportation decision	3.88	0.835
IT assists network design support	3.77	0.934

4.4 SC performance

Evaluating SC performance is one of the criteria for the overall organizational performance measurement. Table 9 depicts mean responses about SC performance conditions in surveyed companies using a 5-point Likert scale. Based on the findings, the five building blocks of SC performance such as SC reliability, responsiveness, flexibility, cost, and asset management were scored with values between 3.50 and 4.50. This implies that the majority of respondents agreed to the fact that the company SC's performance was good.

Table 9: Descriptive statistics of SC performance

SC Performance	Mean	Std. Deviation
Reliability		
We are consistent in solving customer complaints	3.97	0.703
We offer products that are highly reliable	3.90	0.745
We offer products that are very durable	3.90	0.819
We offer high-quality products to our customers	3.88	0.740
Responsiveness		
We deliver the kind of products needed	3.86	0.864
We deliver customer orders on time	4.00	0.771
We provide dependable delivery	3.94	0.709
The time to solve customer complaints is short	3.90	0.768
Flexibility/agility		
We are able to deal with different non-standard orders	3.74	0.755
We act quickly on market changes	3.69	0.814
We are able to produce new feature products	3.75	0.694
We are able to meet our customers' requirements	3.76	0.668
Cost		
We are able to offer prices lower than our competitors	3.92	0.851
Our capacity utilization is very good	3.90	0.774
Our Inventory turnover is high	3.75	0.854
We run operations with less Production cost	3.88	0.573
Asset management		
Knowledge sharing between our business units is high	4.06	0.904
Our organization is centrally managed	4.19	0.919

Intellectual Property (IP) rights are well managed	3.85	1.003

5. Proposal of IT adoption model

This section presents an effort rendered to a theoretical IT adoption based on the empirical find in Section 4. Hence, the researchers were motivated to develop thoroughly a firm-level, combined IT adoption model for MLSM Ethiopian manufacturing firms. The model was developed based on the knowledge gained through the literature review, questionnaire survey, and interview results. It combines existing theories and empirical findings from surveyed firms. The proposed model is named a cup-type IT adoption model (Figure 5).

5.1 Components of proposed model

Generally, the model consists of four fundamental conceptual parts namely increasing organizational change and sophistication, exploiting opportunities and CSFs, minimizing challenges and barriers, and minimizing IT-based risks (e-risks). According to the proposed model, manufacturing firms in the developing world should increase organizational change by adopting IT tools step-by-step along the adoption ladder and should exploit CSFs. Simultaneously, they have to stick to minimizing barriers during the exploitation process and reduce IT-based risks (e-risks)while sophistication.

Increase organizational change and sophistication: It is the first quadrant component on the Cartesian plane in Figure 5 and the advantage of this adoption ladder approach is that it highlights the transformation aspects of technology and the key social needs from which it emerges. Even though the original adoption ladder approach was primarily designed for developed countries like the UK small firms (Parida et al., 2010), it can have a relative significance on MLSM firms of developing countries. To begin an adoption process they need to have a profoundly deterministic view of changes. First, there should be an IT investment strategy, goals, and objectives set by the firms' top management during the strategic planning process. Second, after making sure that a firm is equipped in terms of internal organizational capability, employee fitness, IT necessity, ease of use, and risk management, one can gradually begin from stage one adopting the Internet, then developing own website, e-commerce, e-business and some sophisticated IT applications such as ERP, SCM, CRM, EDI, RFID, etc. (Figure 6).

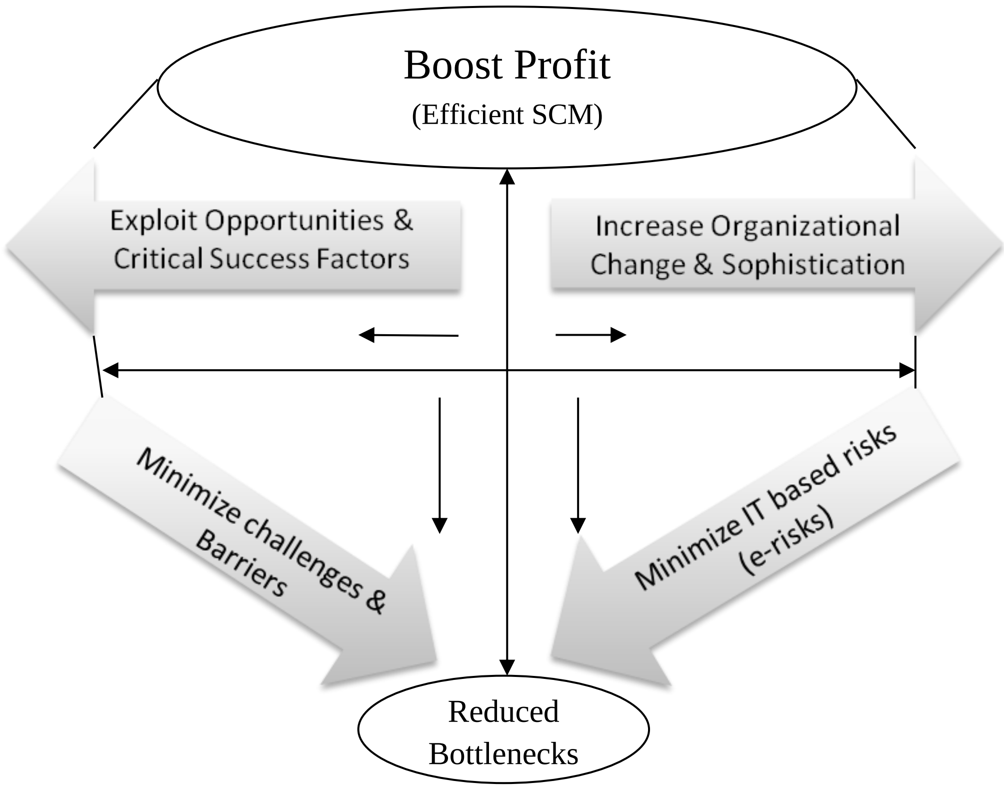

Figure 5: Proposed cup type IT adoption model

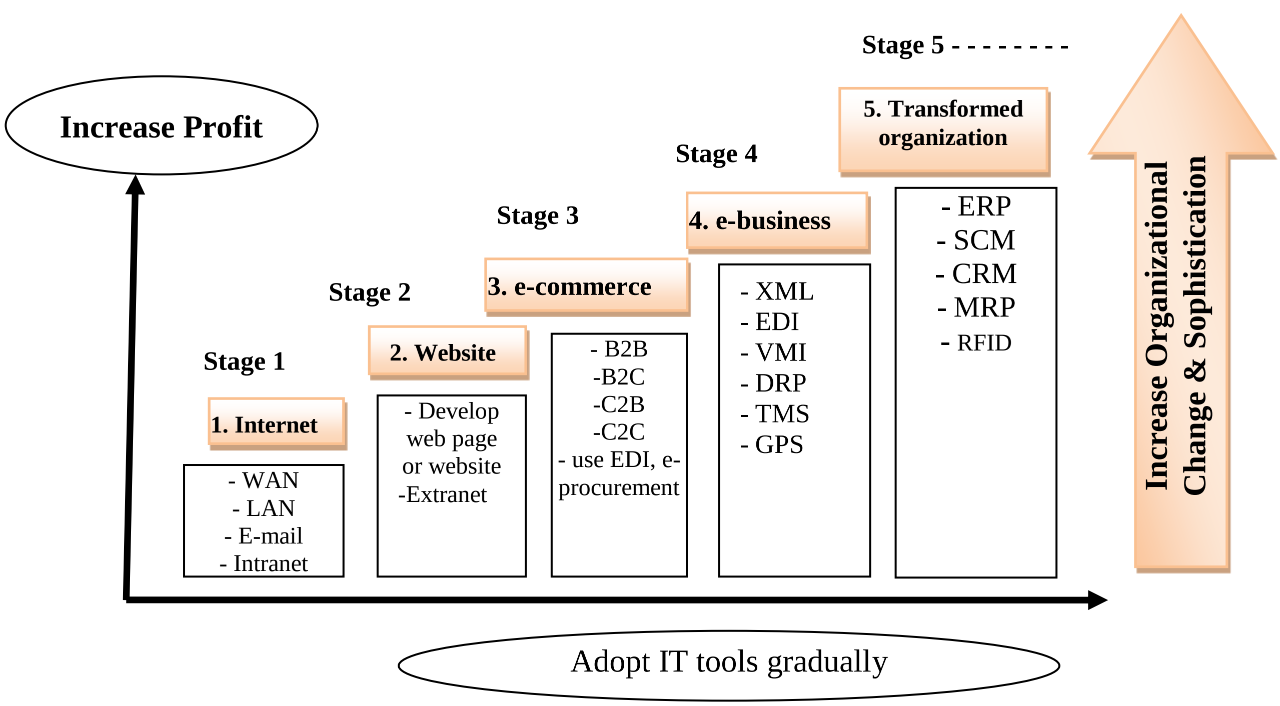

Figure 6: Organizational change and sophistication ladder adapted from Martin and Matlay (2001)

Since technology innovations are dynamic in nature, further sophisticated IT adoptions and transformation are required to provide information to customers, suppliers, and business partners. It can handle multiple complex operations automatically thereby reducing manual handling and could provide supply chain multi-functional roles such as good coordination and collaboration along SC, reliable transaction execution, and decision support for different level managers. Adopting IT systems accordingly with an adequate adoption and implementation procedure can enable firms to boost the company benefits and gain a competitive position as well.

Exploit opportunities and CSFs: This is the basic component (in the second quadrant) that should be considered during an IT adoption process. For every business, there are different opportunities and CSFs. For this particular model, firms can exploit opportunities and CSFs from five dimensions as indicated in Figure 7. Most of them were addressed in Table 7.

- **Individual factors**: A company can find opportunities and draw some CSFs from its employees, such as IT competence (knowledge and skill), willingness to innovate and train, good attitude, and participation among employees.
- **Organizational factors**: Organizational factors such as strategic level plan, top management support, open communication and perception, inter-organizational integration, size, and excess resources (slack) in firms have a significant influence on the adoption of IT. These organizational factors should be taken as opportunities for successful IT adoption.

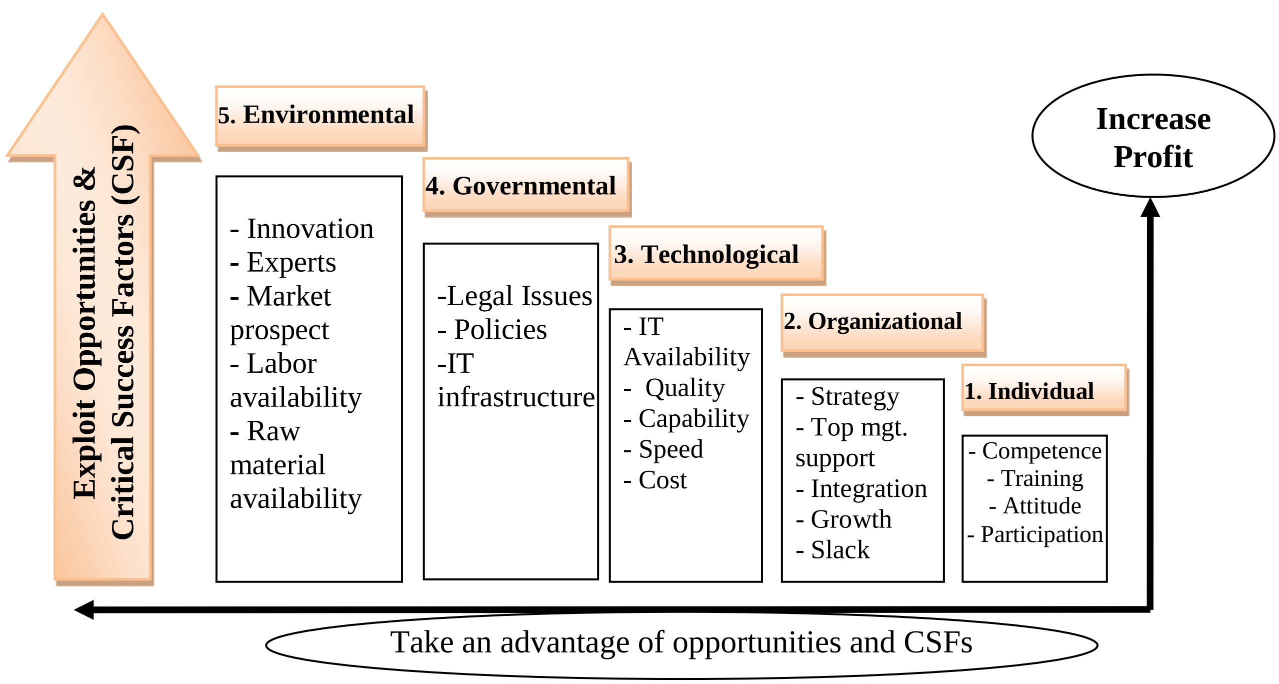

Figure 7: Opportunities and CSFS

- **Technological factors**: If the IT systems that are adopted become easily available, have dependable quality, capable of organizational fit, are highly reliable in accuracy, and at a reasonable cost, then firms can grasp these opportunities easily.

- **Governmental factors**: Governmental incentives like free tariffs, subsidies, national IT infrastructures, and strategic IT development policies are the CSFs to adopt IT systems in firms.
- **Environmental factors**: Process and operation innovations, the availability of IT experts and consultants, industry expansions, labor and raw material availabilities determined as CSFs, and opportunities associated with organizational factors.

Minimize challenges and barriers: The third quadrant component focuses on the risk management part during the exploitation of opportunity and CSFs. Many barriers and challenges might arise while using opportunities and CSFs. Some of them include:
Individual - ignorance of changes and literacy levels

- Organizational – the lack of resources, conflict, and resistance to changes
- Technological – IT security threats and the costs of IT adoption and implementation
- Governmental – regulations and tariffs
- Environmental – globalization, competition, customers' preference, supplier partnership, and trust

Counterpart remedies should be applied gradually to maintain a favorable environment that can trigger all inhabitants of firms. For example, making a substantial effort on regular training for employees and for all level management staff about technology innovation, competitive strategy, customer service, dynamic global market change and most importantly upgrading staff in innovational technology disciplines will help firms minimize those challenges and barriers of IT adoption.

Minimize IT-based risks (e-risks): The fourth quadrant component of the model states about minimizing e-risks associated with SC technology adoption. SC security assurance in the network is a vital concern to every technology-based firm. Bolhari (2009) clarified information theft and demonstrated the details of this phrase. According to this study, information theft contains different items such as viruses, worms, Trojan horses, hackers, Trap doors, Logic bombs, port scanning, spoofs, Domain Name Service (DNS) attacks, social engineering, etc. In addition, there are counter tools, which can secure networks facing those risks. These are using Passwords, Firewall, Virtual Private Networks (VPN), Digital Signatures, Secure Sockets Layer (SSL), Virus Applications, Available Disk Space, Formal Security Policy, Time/Day Restrictions, Restrictions to Location or Workstation, Removing Inactive Accounts, Segmenting LAN Traffic, Encryption, Certification Authorities, etc. Most surveyed firms have already adopted IT systems and those in triumph to adopt are recommended to apply the basic network security triangle, called "Security Trinity" (Canavan, 2001). It includes prevention, detection, and response measures.

5.2 Model implication

The proposed cup-type IT adoption model embraced basic concepts from different previous model theories such as TAM, DIT, UTAUT, TOE, and DTI adoption ladder. The proposed theoretical model combines these theories with practical challenges and CSFs from the empirical findings of surveyed

MLSM firms in a developing nation. It is called the cup-type model because the drawn conceptual framework has a cup shape by asserting two major concepts increasing benefits and minimizing risks. The former indicates the grand collection of profit from an efficient SC attained by properly applying the first two components such as increasing organizational change and sophistication and exploiting opportunities and CSFs. The latter, however, emphasizes a reduction of bottlenecks (challenges, barriers, and e-risks) by employing the second two components such as minimizing barriers, challenges, and e-risks that can exist while applying the first two components.

Regarding time-saving and economic aspects, the model provides a simplified guideline to avoid calculated risks associated with IT implementation by trial and error. IT, generally, enhances customer service by minimizing the bullwhip effect, enabling the right exchange of information along the SC, and enabling an efficient logistics service and inventory management. Therefore, this particular proposed model is expected to reduce the time taken during an IT adoption process and reduces the cost of IT maintenance because it sets out better grounds for identifying opportunities and CSFs that enable firms to consider before implementing any IT tools. Generally, the model sets clear and gradual guidelines and procedures in order to handle associated challenges and risks, which make the model unique from others. For better understanding, Figure 8 illustrates the detail of the proposed model containing all proposed components.

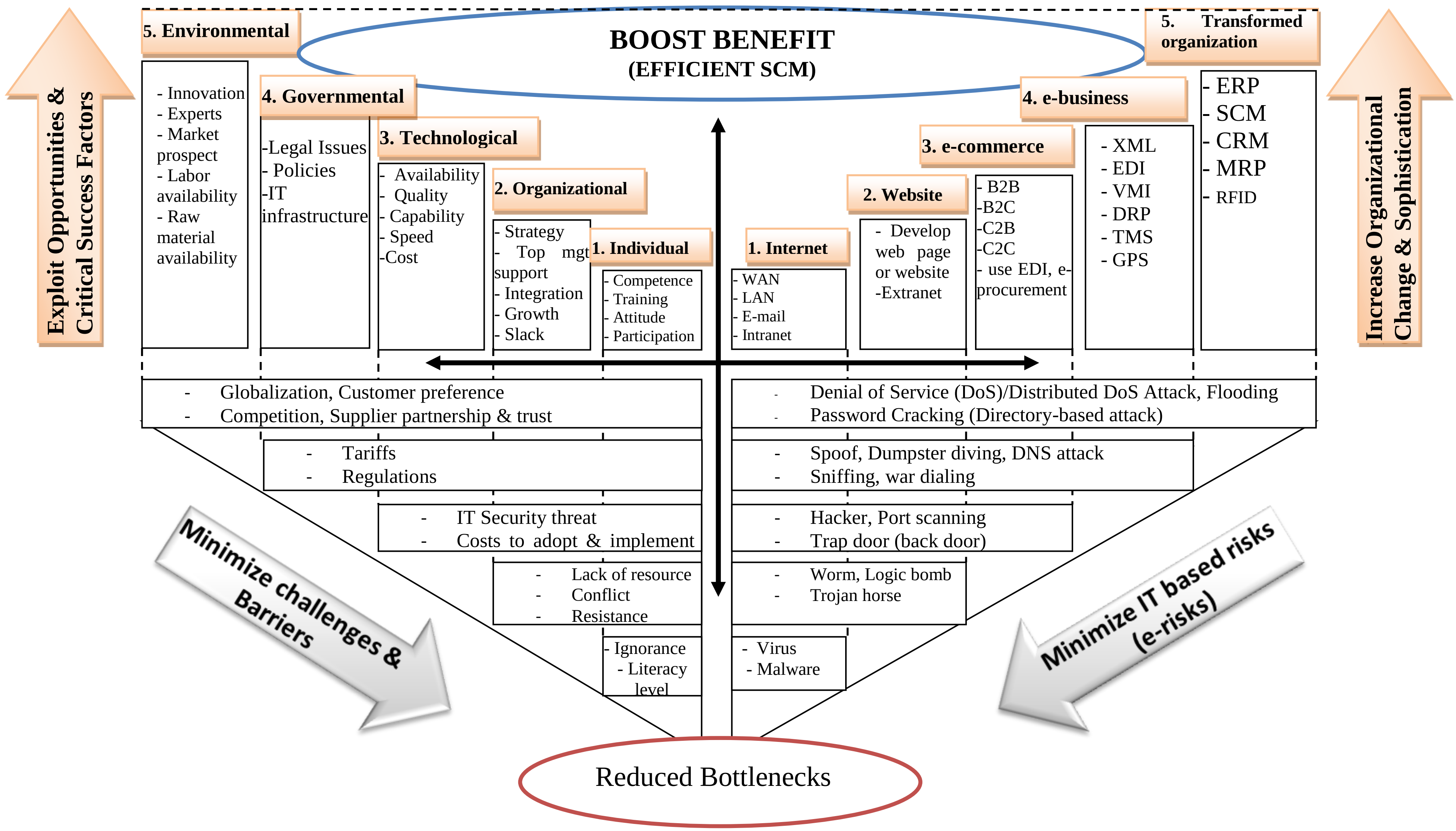

Figure 8: Proposed cup type IT adoption model for Ethiopian MLSM firms

6. Theoretical contribution of the study

The proposed IT adoption model addresses the strengths and limitations of the current theories. Most of these strengths and weaknesses were included during the survey of empirical findings from surveyed manufacturing firms. As stated in Section 2.3, the current IT adoption models (theories) such as the UTUAT or TAM, TOE or DIT, and DTI ladder were developed depending on the problems of industries in the developed world. On the other side, the studies in the developing world were highly concerned with the CSFs and challenges/barriers for IT adoption, and relationships between IT adoption and SC performance using adoption models that were developed to address the problems of firms in developed countries. To the knowledge of the researchers, IT adoption models have not been proposed based on empirical findings and the current theories of IT adoption to articulate the specific problems of manufacturers in the developing world specifically in Africa. This implies that the proposed IT adoption model in this study can bridge this gap by combining the empirical findings of surveyed firms and the strengths of the existing theories.

The current theories can be classified into three major categories according to the literature survey of this study. They were classified as the UTAUT/TAM (individual-oriented), TOE/DIT (firm-oriented), and DTI adoption ladder models (Sections 2.3). The strengths and limitations of these theories were incorporated into the newly proposed adoption framework. From the UTAUT, individual factors such as competence (knowledge and skills), willingness to innovate, and attitudes to accept and use technology are included as an exploration of opportunities and CSFs. In addition, ignorance or resistance to change, and literacy to IT are considered as individual challenges/barriers that must be minimized. Although these are the strengths incorporated from the UTAUT, the UTAUT fails to address issues at the firm level related to technological, organizational, and environmental issues.

To address this limitation, all of the TOE aspects are included as opportunities and CSFs and as the challenges/barriers that must be minimized on the other side (Section 5.1). Although the TOE incorporates many factors for IT adoption, it lacks to articulate how the technology is systematically implemented in manufacturing firms. According to this study, the implementation issue is very essential for surveyed firms referring to the information obtained from interviewing concerned key personnel. To solve this difficulty, the DTI ladder of technology adoption approach was utilized in the new theoretical model. It is accounted as the factor of increasing organizational changes and sophistication for the implementation of the proposed IT adoption model.

The DTI ladder approach mainly focuses on the implementation issues of IT adoption models starting from the use of the Internet (e-mail, LAN, etc.) to a fully transformed organization using the ERP, RFID, EPOS, etc. However, the issues of risk mitigation during the implementation of technology models were not explicitly described. The proposed model uses the Security Trinity model, which includes prevention, detection, and response measures as a risk mitigation tool to minimize IT-based risks.

7. Conclusions

The findings of this paper indicate that the status of adopting IT models among the surveyed Ethiopian MLSM firms is inadequate in general, although improvements are shown in adopting some IT facilities such as the Internet, intranet, web, and barcode scanner services. Significant limitations were observed in utilizing sophisticated IT systems like ERP and decision support systems. Moreover, those firms already adopted some IT systems did not sufficiently utilize them in their business areas. Although the IT adoption and acceptance status of surveyed firms is low, their responses regarding the perceptions towards IT roles in SC performance are positive. This implies that there is a need to accept and adopt sophistication to their business activities. The SC performances after adopting some of the IT tools, their SC performances were improved as correlation analysis indicated in Table 10. In order to adopt IT models successfully, different CSFs and barriers were articulated in this paper.

The CSFs that have supported surveyed firms to apply IT were good innovation culture, open communication system, availability of finance, top management support and involvement, and clear and systematic direction in planning. In addition, the barriers influencing MLSM firms during the IT adoption process were resistance to change, lack of government support, lack of budget, lack of strategic planning perspective, lack of skilled labor, and high cost of technology. The practices of SCM revealed that the concept of SCM in the firms was still new. This indicates that they need IT-based effort (enabler) to facilitate innovations and improve their SC performances shown in Table 10. Depending upon this need, a new IT adoption framework was proposed in this study.

The framework was proposed by integrating the empirical findings from the surveyed firms and well-established theoretical models from the current literature. It was found the current literature lacked to develop a theoretical IT adoption model for manufacturing firms in developing nations based on the empirical findings of their specific problems. However, the effects of IT adoption frameworks on SC performances were widely acknowledged in previous studies, and most of the frameworks were proposed for the developed world. On the other hand, the empirical studies conducted in the developing world concerned with the CSFs and challenges for IT adoption, and relationships between IT adoption models and SC performance based on the existing theories that were proposed to articulate the IT adoption problems of firms in developed nations. This paper bridged this gap by articulating these two important problems. The study proposed a novel theoretical IT adoption model based on empirical findings from manufacturing firms in developing nations. In addition, the proposed model addressed the strengths and weaknesses of the previous IT adoption models (Section 6).

In the future, the researchers will focus on the implementation of the proposed framework in specific case industries to test and validate it. This can highly improve the applicability and acceptance of the IT adoption framework and its limitations can be well articulated after these future works.

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