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Article

Implementation Barrier of Industry 4.0 in Ethiopian Manufacturing Industry: A Literature Review

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A B S T R A C T

Industry 4.0 is opportunity for new job creation and industrial automation not only for developed counties as well as in developing and underdeveloped countries. The basic prerequisite of Industry 4.0 is information methodology infrastructure, strong and supportive government policies and technical skill development for advancement of industrial sector into the digital revolution.

The main aim of this literature review to examine and identify the barriers for implementation and applicability of industry 4.0 revolution in Ethiopian manufacturing Industries and to provide suggestive proposal about the incapacitating from these barriers to successful implementation of Industry 4.0 in Ethiopia.

Industry 4.0 has the huge capabilities and strong potential for the accelerate transformation in the fastest growing economy of Africa. In Ethiopia Despite is still no definite planning and awareness of the implementation and awareness of industry 4.0.But for development and advancement, it is vital for the manufacturing sector in Ethiopia to examine and identify the implementation barriers of Industry 4.0 and find out the possible solutions for barriers so that it can be easily implemented in Ethiopia and can be provide guidelines for policy maker.

There are lots of contests regarding Industry 4.0 in the Industrial sector of Ethiopia. The theory of Industry 4.0 for the Ethiopia is new and not very well established in related literature and practices and this is the main motivation for this article. But for future competitiveness and survival, the concept of Industry 4.0 may be mandatory for Ethiopian companies for better operational performance and enhance productivity according to the competitiveness of global market.

This study will help to the industry practitioners and government of Ethiopia to understand the key execution barriers of Industry 4.0. Most of the available literature related with the Operation problems connected with developed countries but none have specifically attempted to investigate the encounters to the execution of Industry 4.0 in the developing countries like Ethiopia.

Keywords: Industry 4.0, Barriers of Implementation, Developing Economy, Ethiopia

Introduction

In Africa, Ethiopia is the second most heavily populated and economically profligate rising country.[1] This development was driven by government investment in infrastructure, education, agricultural and service sectors with long term planning. Most of the Ethiopia's economy is agricultural based, but now a day's service sector surpassed agriculture as the principal source of economy. In Ethiopia, mostly infrastructure projects related with electric power production and distribution, textile and garment industrial parks. Technological advancements in developing countries basically dependent on the foreign investments and resultant methodology transfer [1,35].In Ethiopia most of the multinational companies are using advanced technologies for production in textiles, leather and other areas and that is foundation of implementation in Ethiopia.[2,3,4]

Industry 4.0 is revolution for conversion of the conventional production system into the automated system based on AI, on which system can synchronize with resources and no need of human interface for the production system.[5]

The Industry 4.0 is combines term and incorporated with communication network, internet, production systems, supply chain and logistic.[6, 7] This term is collection of various production aspects with internet and cyber physical systems. Industry 4.0 is playing major role in implementation of new technologies, whereas the realistic transformation from conventional manufacturing system to smart factories is also challenging aspect for researcher of this term.[8]

The term industry 4.0 or connected industry 4.0, refers to the current evolution of systems, machinery, technologies and processes used in the industrial sector through the use of new technologies: sensors, internet, real-time communication between machines, manufacturing additive, etc.[9,10] It is the mode to entitle the phenomenon of digital revolution applying to manufacturing industries. Industry 4.0 consists of digitizing production procedure in factories through sensors and information systems to modify production operations and make them further competent. The purpose of Industry 4.0 is an ambitious high-tech project, which is to encourage the automation of developed.[11]

The concept of smart city and smart factories generate the demands of sensors and automated system for daily life applications.[12] There are some important elements, which can affect the social life heavily like Internet of things. This things possible communication between machines to machine, this is the important fact by which without human interference production system can be run.

The important thing is automated decision making by machines .This is possible only by sensors and cyber physical systems and basis for machine to machine announcement is possible.

The combination of cyber physical system, Internet of things and machine communication can bring the modifications in the existing production system with capabilities [13, 14]. Machine communication is very strong when machine can communicate with the human and that is possible only with the help of information network, artificially intelligence, intelligent communication and machine human interface.

Methodology

This research paper focused on the implementation aspect of Industry 4.0 and the barriers in unindustrialized economies, on the basis of literature review, books and reports. For carry out extensive literature review and collection of literature, the authors covered engineering, management around 89 related literatures from publication database like Emerald Insight, ACM, Science Direct, Cite Seer X and Taylor Francis with key words like, Industry4.0 component, Industry4.0 implementation, Ethiopian Economy, Developing Economy.

Industrial Revolutions: Background Analysis

The First industrial revolution started in the span of eighteenth century to nineteenth century, with the introduction of machines and it converts in next revolution after application of electricity and starting of concept of management in the labor and productivity.[15,16] Development of electronics and information methodology, started third revolution in end of nineteenth century with automation and use of computers in the area of production.[17] The advancement of digitalization and automation is converted into the "Industry 4.0" concepts with the German imitative for machine to machine communication and development of whole automated system for increase the competitiveness for the German manufacturing industry.[18]

The challenge for this new industrial revolution will then be the development of software, massive data analysis systems and their storage, the incorporation of electronics to the elements that interact in production processes and in the products derived from them, the coexistence of man with the machine and the availability of information for better and more operative decision making.[19,20]

Industry 4.0 also aims to respond to current problems both in terms of energy saving and in the management of natural and human resources.[21,22] With an organized system based on a communication and exchange network instant and permanent information, you will be much better prepared to make this management better and more effective, allowing improvements and, possibly, gains in productivity and economy of resources.[23,24]

Finally, Industry 4.0 as such, is a concept of great complexity, which is not well known in the context of Small and Medium

Enterprises; In this sense, only some topics related to the Internet of Things or CIM or CAD Engineering Systems have been recognized by experts in the field; which does not depend neither on the size of the company, nor on the range of operation, nor on the type of production.[25,26] It is seen in the context that there is only knowledge of the subject at the level of middle managers and managers in administrative and Research and development departments that interact with new technologies.[27]

In the next few decades, the production system will be more automated with full autonomy about the production and quality of the products because the Industry 4.0 not only working on the digitalization and technological up gradation of conventional system but the main areas are artificial intelligence, communication network and automated machine learning so the fully automated and without human interference system can be work on the optimum level for higher production with quality products[29,30].“Industry 4.0” term was introduced by people from numeral areas for intensification the competitiveness of German industries in to the global market.[31,32]

This was the conceptualization of the idea of the smart factories for the emergence of the new approaches for the collaborative manufacturing environment for the benefit of germen industries and increment in the technical competitiveness for fulfillment of up gradation and productivity improvement requirements.[33, 34] The companies also want to technical advancement in numeral areas of production for uniqueness and superiority in the specified productions and products. Similarly, integrated production system equipped with higher methodology and methodologies are the requirement of the companies and for the controlling in all the area of production from logistics to real time based management of resources and utilization of whole supply chain of the system.[35]

The use of sensors, artificial intelligence and strong computer network is the basic requirements of dark factories for full automation and autonomy for level of working competence in integrated automated manufacturing environment.[36, 37] Now a day’s also some factories working on the concept of the dark factories, where no need of human interference in the production but the maintenance and controlling for raw material to the final product human interface is required. But in the case of dark factories no human interface from raw to the final products .[38]

The unmanned factories and used of sensors with automated production system from input to raw material to the final products is the basis of Industry 4.0. The another aspect of Industry 4.0 is uninterrupted information flow across the world and sharing the ideas and product information in secured manufacturing global network for overall development and sharing the technological advancement. The effective and creative utilization of technological advancement is the key factor of success of Industry 4.0.

Some factors and motivations affected the direction and growth of the production system. Social interaction and international trade is the regional factor whereas global flow of financial. Resources comes into financial factor. Technological advancement and conservational and safety issues are another factors, which are the deciding factors for industrial growth in particular areas and economy.[39]

In automated system, the important components like sensors and machines work together with the help of internet and information methodology network. These systems interact and communicate with the help of internet for prediction of failure, repair and modification. This feature enables machine to communicate with other machines and ready to adoption new changes according to the situation and requirements and these is the basis of higher productivity, growing economy with safety.[41]

For the modification and improvement of conventional production system into smart factories requires operational modification into the company’s practices and preparation of significant changes for advancement and related activities for production Industry 4.0 in the existing system. These changes can be come, only after the collaborative approaches of skills and capabilities for the progressive and competitive engineering environment into the industry through the execution.[42] Industry 4.0 is now globally accepted term for advancement and vision for the future manufacturing environment. This can be achieved through coordinated working of the product, network communication and the machine intelligence [43, 44]. For example, the taxi companies, social media platform, e -commerce companies are working on the basis of application of information methodology basis with the use of available resources. The advancement and the growth of this type of services heavily dependent on the software’s and network connectivity and the future and growth of business will increase with the implementation of Industry4.0.[45]

Implementation aspect of Industry 4.0

The major components of the Industry 4.0 are Cyber Physical Systems, machine communication Smart Factory, Cloud Systems, Internet of Things and Big data. There are some studies regarding the road map and execution aspect of Industry 4.0 in the literature about the planning tools for manufacturing of Industry4.0.

- For integrated and collaborative work between numeral companies the standardization of system and interconnectivity is primary requirement for sharing and utilizing the information through secured

manufacturing network.[46, 32, 22]

- The smart companies will be very complex and complicated system and without appropriate plans and efficient optimization model management and resource utilization is very difficult.[47, 35, 28]
- Internet is the most basic requirement of the implementation of Industry 4.0 and existing broadband services not enough to fulfillment the requirement of smart factories and smart companies. Development of ample and reliable internet network is another requirement for implementation aspect.[48,49]
- Environment friendly manufacturing facilitates is the condition of the implementation of Industry 4.0 and safety will assure about the unauthorized use of products and service.[50,34,25]
- Production management with the pre set goals of process, working environment, automation for full utilization of available resources for higher productivity and quality assurance.[51,17,26]
- Industry 4.0 is the rapid and continuous improvement process and for the work force and employees needed better training and professional development opportunity.[52,53]
- Development of organizational framework for personal data, trade information and structural information. These are the necessity of the appropriate control measures for the organization working and employee coordination's.[54,55]
- The productivity improvement is the main measurement for the efficient system and for this purpose increment in resource utilization by new methodology, process and raw material and reduction in any losses due to production system or working environment.[55,56]
- The minimum human interaction is the basis of automated system and the successful implementation can be in view of only basis of amount of human interference for operating the system.[57,55]
- The synchronization of working environment between the process and machines is the basis of automation system.[58]
- Big data analysis and handling capability is the basis for the smooth running environment of the smart factories for achieving goals.[58]
- Methodology adoption and flexibility capabilities of machines and system can be work under changing environment and simultaneous operations. Collaborative and coordinated automated system is necessary of machine to machine communication and reconfiguration of system.[59,17]
- The existent time CPS platforms and social infrastructure grounded on smart interacted model can generate a pure and noticeable roadmap for alteration of present system into Industry 4.0 with Enclosure of supply approach and leading market strategy into industrial strategy.[59,23,35]

In Industry 4.0 some technologies are playing big role and for the implementation aspect these technologies very important like reality, big data analytics , industrial internet of things, robotics, machine learning , simulation, cloud computing, cyber-security, additives manufacturing, etc.

Autonomous robot is another important tool for Industry 4.0 implementation. Robots are very helpful in performing those operations, which is very difficult for human being for numeral reasons like harmful working condition. Now companies are performing repetitive operations by robot in manufacturing plants.[60, 35,56]

Simulation is the artificial replication of the any developed operations or machines, man, and products related activities.[61, 25, 36] Its applications in numeral fields like development simulation, optimizing process, and scientific modeling for understanding and visualizing the system. Simulations also using for ergonomic design, method study and energy consumption pattern .The use of simulation can help in minimization breakdown time, waste minimization and higher quality output.[62]

Internet of things playing important role in industry4.0. Internet of things can be defined as an industrial internet in which Manufacturing Service, People and communication devices are networked for controlling and operation.[63,39]

For effective employment and working in Industry 4.0, every components should be connect with each other and communicate through a standard protocol for production determination. To protect this information about machines and operations, cyber security should be more secured, advanced and reliable.

The cyber physical systems used for connect physical components to digital control. It is used for the physical connectivity of components.[64]

Cloud computing is another tool for storage of real time massive data from all the operational source of manufacturing system .It is used for share communication devices and component for operations and controlling .The implementation of Industry 4.o can be achieved through cloud computing networked devices.[66,41]

Additives engineering skills are important for cheaper and faster production especially in the case of prototype or batch production for example selective laser sintering, fused deposition method. The fast changing customer requirement can fulfill by application of additives manufacturing in less time and efforts.[67,34,17]

Augmented reality is a network of communication devices, which helps in the manufacturing system for collecting real time data. It improves the controlling over the system through collection of real time data and support in decision making process and best suited for upkeep operations and modification process.[68, 45]

Machine learning is basically software and internet based methods that can collect the necessary info from a manufacturing system.[69] Its important role in predictive conservation and breakdown investigation and for various purposes like fault diagnosis on gearbox.

Now the all new technologies and new researches based on the conceptualization of the smart factories and use of methodology for expansion of autonomy and higher quality production but new methodology not much capable of significant change in the existing system and for the conversion of the existing system into advanced system. In the time of volatile market and demand of high quality, now also this is necessary to adoption of new methodology for flexibility and survival in the competitive market.

The various researcher and industrial practitioner contributed for growth the concept and term of industry 4.0 and now this is the main objective of companies for the possible enlargement and up gradation of methodology for the better future and fulfillment of highly quality products demand of the customers.

Smooth however there are heaps of labors to deliver for a rudimentary meaning of industry 4.0 but till the alterations and change for the clear and visionary definition of industry 4.0 awaited. In the conceptualizing of the industry 4.0 there are numeral aspects of researcher, some researcher considering the network communication is important whereas other are giving importance to artificial inelegancy, autonomy and this is the main difficulty for proper and well accepted definition forming of the industry 4.0.[69,45,32]

The new inventions in sensors devices, information network, and machine to machine communication are the basis of speedy progress in the field of robotics and machine automation. In the universities and research centers are working on the adoption and implementation in the field of supply chain, integrated manufacturing, logistic, and wide range of other applications.[70]

Intended for the technical development and implementation aspect of new technologies, researcher focusing on the emerging areas in the cloud computing, big data analysis, Iot, cyber corporeal system, smart factories and cities, only with the development in this area Industry 4.0 can be implemented in numeral aspects.[71]

Scientist also working on the area like decomposing of moment tensors, discrete optimization, Non convex path and optimization, machine learning for the solving various problems related with the implementation problems.

Now in the development of cloud computing, process over time is also improving because it can provide access to modeling, filter and optimization of shared data in the network.

Barriers of Implementation of Industry 4.0

Industry 4.0 is new perspective for the developing economies and without proper planning and accumulation of resources, effective employment or development of infrastructure for this determination is very difficult. Based on the literature some major barriers in implementation of Industry 4.0 are identified (Figure 1).

Lack of Qualified workforce

In the developing countries the most of the companies working on the basis of cheap man power but in the automated system major focused area labor substitution, this factor is applicable in developed economy but in the developing countries the joblessness of unskilled labor is big issue and with the advanced methodology and information methodology application, this problem will increase.[72,54,63] The another problem related with manpower is non availability of qualified and skilled workforce, in the implementation stage of Industry 4.0, skilled work force is essential requirement. Now the available manpower is related with conventional production systems and skill growth is very difficult task. Available jobs in the existing industrial sector are prone to be automated after technological up gradation.[73,46,2,5] The other jobs will comprise more technically qualified as well as upgraded skill.[73,67,3]

High Capital Investment

The funding for knowledge up gradation and adoption is another problem especially in small and medium industries in emerging countries. Most of the methodology not available in the own country, so the cost of components depends upon international market.[48]. Investments in Industry 4.0 is not very easy for companies due to rapid changing market and potential possible losses [74,59,1,2].

Working Culture

The working culture in the developing economy and the requirement in the smart factories, are entirely numeral and the cope up of the organizations with rapid transformation in every aspect will not easy task. The organization structure and culture should be upgraded to the technologies changes and multinational culture.

Organization functions may alteration according to the requirement and decision making depends upon analysis of data.[75,54] The decision making process and use of data analysis for integrated working significant challenges for the companies and the organizations.[76,56,67]

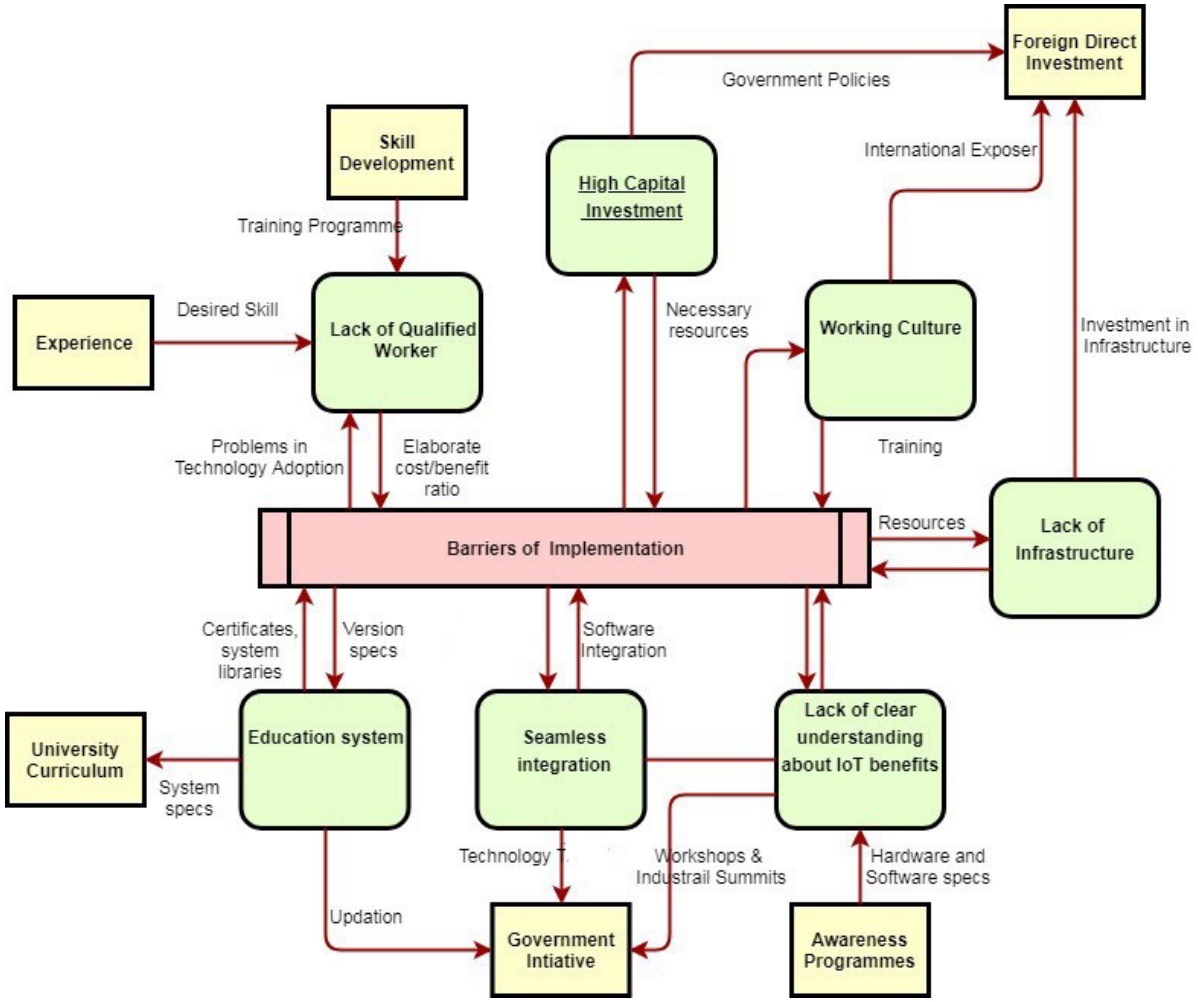

Figure 1.Barriers of Implementations

Decision making process also influenced by analysis of real time data and artificial intelligence but for the conventional working culture handling of the real-time data is not easy task.[77,78,2,3]

Lack of clear understanding about benefits

Industry 4.0 is basically a network of physical components in the system embedded with actuators, sensors and connected through network for communication and data exchange. The adoption in new establishment is potential benefit but in existing system application and adoption is difficult and expensive. The Internet of things variation available in the IoT technologies, so component selection and implementation are not the easy task.[79, 34,1,45] IoT methodology now also in initial stage and developments is still going on.[78] There is also uncertainty about profit from the investment in IoT, so for companies it is quite difficult in developing countries.[80,18,37]

Lack of Infrastructure

Reference architecture is the important and perplexing obligation for the application of Industry 4.0. In case of wireless sensory network, there are lots of problems in standard and reference architectures.[81,21,42]

The adoption of new technologies requires skilled worker, management as well as infrastructure facilities like internet, power supply and network of road and railway for efficient supply chain of the industries. Deficiencies in the requirement of infrastructure prevent the extensive adoption in developing countries.

In the implementation of Industry 4.0, qualification and methodology based skill is the key factor in smart factories.[82,45,2] Skill development and qualified workforce is another big hurdle of implementation of Industry 4.o in developing countries.[83, 54, 67] Efficient working of internet based operations require a lot of skill work force from engineering and non engineering areas.[84,85,3]

For example, Internet is essential requirement of implementation of Industry 4.0 and only effective and interrupted internet can provide effective communication and signal controlling in the system[86,3,5]In developing

countries the internet infrastructure and speed is not up to the mark in all areas of country.

Security and Privacy Issues

The cyber security and privacy issues are another critical matter on Industry 4.0 platform due to huge amount of data flow and business confidential information's.[87,68]Cyber security is very critical aspect of cyber physical system due to recent advancements in hacking and cyber attacks.[87,78,65]

The conformity of related cyber law, regulation for the safety and security of companies and data is major barrier in implementation aspect of Industry 4.0. A company avoids the strict compliance rules and regulation in the case of financial obligation. Companies should be ensure the Information methodology security with man and machine.[88,71,52,53]

Methodology Adoption

Seamless integration is the primary requirement of the up gradation of machines and equipments. A problem in adoptability and seamless integration is important barrier in the implementation and adoption related issues of Industry4.0.[89,2,3]

Conclusions

Ethiopia, as one of the potential African nation state and Industry 4.0 can be used for sustainable changes in country for solving many difficulties. But without proper infrastructure and environment, the country will not only fail to benefit from global opportunities, but will also face the risk of being marginalized furthermore from the world's economy. Ethiopia should therefore establish effective policies to create an environment for the development of Industry 4.0.

There is lots of literature available on Industry 4.o, yet there is an also scarcity of extensive studies and literature for employment aspect of industry 4.0 in case of emergent countries.

The main focused area of this research paper is identification of barriers in implementation of Industry 4.0 in developing countries, some barriers may not have been considered because of irrelevancy. The finding of this research offers important implications for the Ethiopian Industries and if the industries can focus on problems and start the work for minimizing the negative effects, the industry 4.0 implementation can be start in small scale.

Practical implications

- Fast and cheap internet network: In the Ethiopia, now problems in internet and the rates also high and for advance supply chain system throughout the country, need to fast and cheap internet network
- Research and improvement: Ethiopia has been adapting new technologies according to the industry and international availability but for implementation, the basic need is methodology development in Ethiopia.
- New zone in Industrial parks: Ethiopia is developing industrial parks for every sector and numeral areas of country. For promotion and motivation of adopting industry 4.0, some areas may be reserved for smart factories and learning factories, it will help for creating healthy supporting environment and can be develop as skill development for future work force.

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