FACTORS OF DIGITAL READINESS AND ITS IMPACT ON ADOPTION OF INDUSTRIAL INTERNET OF THINGS.

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Abstract: The economy of the world flourishes as of now because of the advents that have happened post industrial revolution. It has indeed paved way to the growth of many industries on a large scale, mostly in manufacturing and processing. Industries like the oil and Gas sector, chemical sector, Heavy Machineries, Defence, Aviation, Energy have all thrived over the years and the scalability has reached a peak. But all these industries are facing issues with availability of resources, and hence it becomes an essential factor to make the best use out of what is left. Many industries have faced the heat of technological adoption and are now stuck in the dilemma of whether to go forward with the move or not. The idea still seems like a sudden initiative for many industries, but that is not the case anymore. This project focusses on identifying the major factors that contribute towards evaluating the Tech readiness of industries and thus provide a road map that shows where an industry or company stands by segregating these factors into Digital Readiness Stages thus giving clarity to industries and tech companies. The project also aims to identify the major drivers of Industrial IoT adoption within such industries and incorporate it into the stages of digital readiness, thereby achieving sustainable transformation through enhanced digital processes. Several Empirical studies outline Industry 4.0 technologies and its use in the industry, but no extensive work has been done in identifying factors leading to the need of such technologies. A qualitative research was conducted by interviewing 20 industrial experts focusing on parameters derived from previous work. The study outlines major factors and classifies them as Technical and Non-Technical factors. Major drivers derived include Data possession, Industry 4.0 Awareness, Tech diffusion, Industry Infrastructure and Technical environment and leads in demarcating the various stages of digital readiness. The study on Industrial IoT adoption resulted in identifying Data and its format, Equipment life, workforce skill and diffusion, Human intervention and safety as key drivers. The study also highlights the impact of Quality and Yield improvement in adopting technology. This study identifies key drivers and the results can be implicated for any future study to be conducted on similar research.

Keywords: Digital Readiness, IoT, IIoT, Tech Adoption, IoT Adoption, IIoT drivers, Artificial Intelligence
1. INTRODUCTION

IoT is a network that connects all physical items to the internet via network devices or routers and exchanges information. IoT enables remote control of objects across current network infrastructure. IoT is a very excellent and smart method that decreases both human effort and provided simple access to physical appliances. This method also has an independent control function that allows any device to regulate without any sort of human interaction.

The term “Things” in the IoT sense, is the mixture of hardware, software, data, and services. It can refer to a wide variety of devices such as DNA analysis devices for environmental monitoring, electric clamps in coastal waters, Arduino chips in home automation to many more. These devices gather useful data with the help of various existing technologies and share the collected information between other devices. Examples include Home Automation Systems which use Bluetooth or Wi-Fi for exchange of data between various home appliances.

Because IoT enables devices to be remotely controlled over the internet, it established possibilities to connect and integrate the physical environment directly with computer-based systems using sensors and internet. The interconnection of these various embedded devices will lead to automation in almost all areas and enable advanced applications as well. With decreased human intervention, this brings in enhanced precision, effectiveness and financial gain. It includes systems such as smart grids, smart homes, smart transport and smart cities.

The major benefits of IoT are:

- **Improved Customer Engagement** – IoT improves customer experience and engagement by automating actions and processes. For instance, any issue in the car will be automatically detected by the sensors. The driver, as well as the manufacturer, will be alerted about it. By the time driver reaches the service station, the manufacturer will make sure that the faulty part is available at the service station.

- **Technical Optimization** – IoT has helped a lot in improving technologies and making them better by gathering necessary data from devices installed and interpreting the inefficient means that derive results. A manufacturer of any car company for instance can collect data from different car sensors and analyse them to improve their design and make them much more efficient.

- **Reduced Waste** – IoT provides real-time information leading to effective decision making & management of resources. If a manufacturer finds fault in multiple engines, he can find the manufacturing plant of these engines and can rectify the issue with manufacturing belt, thus saving a lot of material and cost.

Fast forward to 2020, and the utilizations and areas of application of IoT have drastically improved. Ranging from day to day activities like commute to industrial applications, the scope of IoT has indeed been a boon to this generation. This has led to a lot of new budding companies as well offering IoT driven solutions to industries that are ready to adapt the same technology. Companies have discovered how to collaboratively utilise IoT along with other Industry 4.0 technologies to achieve the best outcome. Often AI and IoT are seen clubbed together and regarded as a complete automated brain behind many processes.

Due to its rapid inclination towards industrial purpose, Scientists have coined a new term, Industrial IoT or IIoT that has been used in various industries like Oil and gas, Chemical, Aviation, Defence, Heavy Machinery, Transportation, and much more. The following report focuses on a product called Cerebra that is an integrated software of AI, IIoT and analytics that is helping many global industries save millions of dollars by implementing it in the manufacturing and production lines.
2. LITERATURE REVIEW

(Hackos 1997) through this paper brings into light the importance of strategic planning for any industry or firm and it is interrelated with adopting technology. Despite the best intentions, most information-development organizations find it challenging to assess their own strengths and weaknesses. The author conveys that it’s not only about adopting technology, strategic planning mainly deals with an organization figuring out when and where to adopt the same. The “when” and “where” part can actually prove to be game changers later on either leading to the overall success of the firm and giving it a competitive advantage over others or can even lead to a company’s failure if things go wrong. The author describes 5 levels of process maturity such as ad-hoc, rudimentary, organized and repeatable managed and sustainable, and optimizing. In order to move into or transition along the path of digitization, firms must know where they stand in terms of technology.

(Genus, Nor 2005) through their paper highlight an important aspect when it comes to Digitization, “The Digital Divide”. According to them it is a phenomenon associated with disparities between groups and societies in the adoption ad diffusion of electronic information and communication technologies (ICTs) and e-business practices. They state that the innovation, adoption and diffusion of ICTs bear the stamp of technological determinism which in a way is a technical imperative in which social, economic and political factors are underplayed.

(Moolman & Blignaut, 2008) talk about the e-readiness of warehouse workers in this paper. A lot of organizations seek e-learning as an alternative to conventional training programs because of its cost effectiveness. e-Readiness refers to the accessibility and availability of IT infrastructure to support activities which allow people to engage in the international global network.

(Yunis et. al 2010) through their paper focuses on the Information and communication technology maturity and adoption as a driver to global competitiveness. The paper investigates the socio-economic and technological factors that are most likely to be associated with ICT maturity, and then assesses their role in driving the global competitiveness forward. The paper also aims at identifying factors that determine ICT maturity. Some factors according to the authors include quality of ICT equipments used in the firm, R&D spending, technical environment, IT education among employees of the industry, diffusion and acceptance levels of technology among workforce, stress on having competitive edge etc.

(Pardo, Potnis 2010) through their paper maps the evolution of Digital Readiness assessments. According to the authors, some factors they consider important while assessing digital readiness where claims of past success while using any digital initiative. This factor caters to two aspects, whether there was any previous adoption of technology, and if so why the industry decided to/not to move ahead with further digitization. Possession of Benchmarking tools, Web measuring indices, telecommunications infrastructure, e-participation indices for employees, Accuracy level achievements in operations are some main factors that help in assessment of Digital readiness according to the authors.

(Constand, Gilbert 2011) through their paper focuses on the relationship between a country’s e-readiness environment and entrepreneurial activities. Their framework includes the following six dimensions of Digital - readiness support: (1) knowledge and innovation (education, research, and public/private partnerships), (2) infrastructure (broadband, cable, telephone, cellular infrastructure), (3) regulatory and financial infrastructure (ease of transacting transborder business), (4) skills distribution network (e-readiness educational opportunities and variety of SME business applications), (5) government e-services adoption (as a model for private sector adoption), access to content (access to educations, private and government data) and (6) measurement problems (associated with measurement of e-readiness and use). Six societal factors that come into picture include economic prosperity, technological innovation,
education, internet server provider (ISP) competition, legal environment, and information technology penetration into society.

(Haug et. al 2011) through their paper talk about Digital Readiness in Small and Medium Enterprises. (Chan and Ngai, 2007) describe the relevance of “technological factors” and “organizational factors” in the context of IT being the equivalent of the internet as “an aggressive technology policy, [and the] compatibility of the internet with organizational culture and infrastructure and top management support were the most significant contingent factors affecting internet adoption”. According to Haug, some prerequisites when it comes to digitization include Revenue, assessing technological capabilities of competitors, understanding the risk involved, having IT related education, prior experience from using IT, having Time bound operations that need to be controlled.

(Liang, Li, 2013) talks about the various prospects of the Internet of Things. The IOT refers to information sensing devices, such as radio frequency identification (RFID) devices, infrared sensors, global positioning systems, laser scanners, and other devices combine the Internet to form a huge interconnected network.

(Whitmore, Agarwal, Xu, 2014) highlights the importance of the basic functioning internet and various web languages as forms of interconnectivity. While Web 2.0 currently dominates the Internet, scholars have been working towards another goal, commonly referred to as the Semantic Web and sometimes referred to as Web 3.0. The goal of the Semantic Web is to markup web content in a way that makes it understandable by machines, allowing machines and search engines to behave more intelligently. Adoption of web 3.0 leads to adoption of IoT, Cloud and Artificial Intelligence.

(Yang et. al, 2014) through their research paper talks about evaluating Digital readiness by analysing digital instrumentation and control systems. Technology readiness has great advantage to analyse the risks in the system development process. The TRLs is a systematic measurement used to assess the maturity of a particular technology and the consistent comparison of maturity between different types of technologies in a system. The study also talks about evaluating technical experts within an industry to understand their position of digital readiness. Companies having positions like Chief technical officers have a high chance of already implementing major tech initiatives within their respective industries.

(Guidice, 2015) talks about how Internet of things is changing the way we perceive business process management. Through his paper, he stresses about the growing relevance of the “IoT”. It arises from the possibility to connect people, goods and operations through a global network. He highlights the competitiveness of markets and the need of intelligent equipment, expert systems and technology. The author stresses on the term “Technological Revitalization” as a new approach to accommodate management propensity to innovation, (Schiavone, 2013)

(Tiwari, Singh 2016) in their paper talks about the various segments where Internet of Things can be applied. In addition to that, they have also provided a chart highlighting all the emerging technologies which act as either prerequisites or must haves for the adoption of IoT solutions. These technologies will help evaluate digital readiness of industries. These technologies include cloud computing, machine to machine communication services, nfc, Big Data, text analytics, etc. they have highlighted how productive each technology will be in the adaptation stage. The development of the IOT cannot be separated from cloud computing.

(Schumacher, Erol and Sihn, 2016) through this paper highlight a maturity model for assessing the readiness of Industry 4.0 and the maturity of manufacturing enterprises. The maturity model developed in this paper enables manufacturing companies to collect data regarding their current state and strategies used with respect to Industry 4.0 which would help extract potential factors of success.

(Preda et. al 2016) through their paper talks about the impact growing use and impact of information and communication technology on innovation performance. The paper put forwards two terms in order to evaluate the innovation levels. The first being Summary
Innovation Index (SII) and the second being Networked Readiness Index (NRI). The Summary innovation Index evaluates Digital innovation capability based on the existence of innovation leader and followers within an industry. NRI constitutes a set of parameters that help evaluate readiness like Environment, Usage of the industry, Potential impacts and infrastructure (Santos, Sales 2017) through their paper aims at evaluation whether adopting IoT itself is a new technological position. Having IoT solutions adopted within a company can be a final stage in assessing Digital Readiness as its implementation makes sure that the particular industry is far ahead in terms of technology adoption and knows how to make real time decisions based on assessing data and thus decrease error and increase operational efficiency and effectiveness.

(Miraz et.al, 2018) brings into picture a whole new concept, Internet of Nano things. The current statuses and future promises of the Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano-Things (IoNT) are reviewed and summarized by the authors.

(Maresova, Soukal, Svobodova, et al, 2018) talks about the growth of Information Technology and how the boom has led to the 4th Industrial revolution. The prevailing interpretation of Industry 4.0, however, refers to new technologies, digitization, and robotization. (Lu, 2017) lists the following areas relevant to Industry 4.0: Internet of Things (IoT), cyber physical system (CPS), information and communications technology (ICT), enterprise architecture (EA), and enterprise integration (EI). Industry 4.0 will have a strong impact along whole value chains and provide a set of new opportunities regarding business models, production technology, creation of new jobs, work organization, and workflows.

(Pflaum, Gölzer 2018) stresses the importance of Data in contemporary world and how it is the fuel to any IoT driven Solution. The author also elaborates about Digital Transformation within industries. According to them, Digital transformation in an industry typically follows a technology-driven “bottom-up” approach. Digital transformation affects a firm’s strategy, its offerings, the IT infrastructure, the way to collaborate with partners, its organizational structure, overall process organization, and core competences, as well as the overall company culture at the time.

(Sargut 2019) in his study talks about his perception about Digital readiness in Small and medium sized companies and scope for further digitization. He highlights that companies should take into account their operational processes and should be able to analyze it to its full extent and determine whether there is any scope of improving efficiency, if so how. The answer always lies with digitisation and adoption of Industry 4.0 into conventional manufacturing lines. The paper also stresses upon the necessity of having clean data for AI driven solutions as well. Some factors contributing to technical readiness include digital, well organized and clean data; accurate and functioning interfaces between those datasets; to have a higher quality of the datasets, the bigger the data base the better it is; and a functioning and fluently working ERP-System (cloud based etc.).

(Gershenfeld, Krikorian, & Cohan, 2004) talks about a completely new concept that would disrupt the way things flow in the conventional world. They stress upon a new kind of network connecting everyday devices and call it the “Internet – 0”. Through interconnectivity of devices starting from the premises of a household, control over objects become effortless and easy.

(Borgia, 2014) has highlighted that the Internet of Things is a new model that combines aspects and technologies from different approaches: ubiquitous computing, pervasive computing, internet protocols, sensing technologies, communication technologies and embedded devices, which are merged together to form a system where the real and digital worlds meet and are continuously in symbiotic interaction.

(Prisecaru, 2016) through his paper talks about the challenges faced by the Fourth Industrial Revolution. He includes Internet, 3D Printers and Genetic Engineering in his definition of the 4th Industrial Revolution. The paper highlights the term “Green Energy” through utilization of technology. He mentions that Information and Data constitute the main ingredients of this new
era and that social media platforms have immense access to the same which poses as a threat to security. A lot of new innovative competitors have rapid access to digital platforms of research & development, marketing, sales and distribution and they may quickly improve the quality, price and distribution of their products and services making use of this. Consumers are more and more involved in the production and distribution chains, they may easily connect to suppliers by means of digital technological platforms, which may pose a risk to conventional players. 

(Ray, 2016) talks about the values generated by implementing Internet of Things on an industrial Perspective. A new term itself has been coined when using IoT solutions in industries, called the Industrial Internet of Things (IIoT) which works in close collaboration with Artificial Intelligence programs. She talks about leading IT players like Microsoft, CISCO, Intel, Oracle, IBM etc., inclining their focus to a new buzz word “IoT Cloud” which means cloud enabled IoT. Through the utilization of Cloud based systems, companies will be able to control operations worldwide by sitting in a different part of the world. 

(Kaur, 2017) through their paper outlines the future trends and scope of Internet of things. Through their study they have pointed out that Internet of things (IoT) provides a communication platform supporting person to person (P2P), Machine to Machine (M2M) and Person to Machine (P2M) interactions. It has a nominal intervention of humans. It is a network where miscellaneous things like animals, plants, vehicles, appliances, buildings etc. exchange information via the internet. IoT makes surroundings smart by exploiting RFID tags, sensors, mobile phones, Internet protocols, and wired or wireless communication technologies.

(Müller et al. 2018) in his study indicates that strategic, operational, as well as environmental and social opportunities are positive drivers of Industry 4.0 implementation, whereas challenges regarding competitiveness, future viability, as well as organizational and production fit impede its progress.

Industry 4.0 provides new paradigms for the industrial management of small and medium enterprises (SMEs). SMEs find themselves ill-equipped to meet these new opportunities regarding their production planning and control functions (Moeuf et al. 2018).

(Shukla et al. 2018) in their paper talks about the rapid evolution of IoT over the years and its integration with Artificial Intelligence. The author tell that IoT traces its history from technological advancements like RFID, NFC, Wireless sensor Networks, Nano Technology and finally Smart Technology. Nowadays, IOT smart system produces large data that can’t be processed with usual data processing algorithms. Artificial intelligence plays a major key role in various fields like monitoring, healthcare, industrial evolution, weather analysis, social network analysis, decision making, market prediction, research and development. The IOT and Artificial Intelligence (AI), together play a vital role in the coming years.

(Zacher, 2019) sees Industrial Internet of things as major drivers of business opportunities in the digital Economy. Smart technology is having a growing impact on every aspect of life. The author highlights the fact that early adopters of this technology and the use of it in their respective industries will mark the way in which that industry will sustain and grow and further establish a competitive market as well. He describes the industrial internet of things as “the marriage between the digital and physical world.” Alongside, he also stresses the necessity to keep the human element within the system to add the factor of experience to the overall equation.

(Chou, 2019) through his paper highlights the various technologies under Industry 4.0 that can be used in manufacturing lines to achieve greater productivity. Among these he includes Internet of things. To be precise, Industrial Internet of Things, Cloud based technology and Artificial Intelligence.

(Morrar, Arman, Mousa 2017) through their paper talk about the rapid pace at which technological advancements are being adopted in various manufacturing processes across various industries. All this is due to the boom created by the 4th Industrial Revolution leading
to adoption of technologies like cloud, AI, IoT, Big Data Etc. The study also talks about the inter relation between social innovation and Industry 4.0 by considering social, economic and environmental factors. (Schmitt, 2015) confirmed five reasons why Industry 4.0 is important and is seen to be revolutionary in the era of information technology and open market operations. First, Industry 4.0 mitigates the burden of current challenges for manufactures in order to make the companies more flexible and responsive to business trends. Second, Industry 4.0 enables the transformation of modern economies to become more innovative and hence increase productivity. Third, it highlights the role of consumer as a co-producer and puts them in the centre of all activities. Industry 4.0 puts humans in the centre of production. Finally, we argue that it will enable sustainable prosperity with modern technologies to find solutions to the challenges related to energy, resources, environment, and social and economic impacts. Innovative solutions can reduce energy consumption, help companies to sustain their business with existing and new business models, and use new technologies to produce all over the world (even at high-cost locations) close to the markets utilizing the domestic workforce skills.

(Jeyanthi, 2018) specifies the Internet of People, Things & Services (IoPTS) as the visualization where people, things and services are effortlessly integrated into the internet as active participants which exchange data about itself and their perceived nearby environments over a network-based infrastructure.

(Shim, 2017) defined smart factories as an integral part of the fourth industrial revolution which is necessary for operating and manufacturing systems sustainability while considering major factors like satisfaction of customers, quantity and quality which are being majorly affected by production scheduling.

(Guo, Lu, Gao, & Cao, 2018) proposed the concept of Smart City with its enablers and also stressed on the Semantic Internet of Things using Artificial intelligence (AI – SIoT) service framework. The introduction of AI will help in identifying people’s lifestyles and choices and IoT will help in enabling the smart devices to learn about individual’s activities and intentions. (Schaefier, Cheung, 2018) in their paper talks about smart packaging, its underlying technology, benefits and limitations. Smart packaging refers to packaging systems with embedded sensor technology used with foods, pharmaceuticals, and many other types of products. Sensors helps to monitor freshness, extend shelf life, improve product and customer safety, and display information on quality.

(Witkowski, 2017) stressed upon innovative solutions for the challenges faced in IT solutions implementation in logistics. The different types of technologies outlined in the study are Industry 4.0, IoT, Innovation in logistics, and Big Data. In innovation in logistics, various factors were considered for continuous improvement, which are responsible for innovation activities like constant vigilance over the quality of activities, work satisfaction, activities relating to constant improvement of process in logistics and constant focus on work team. In IoT, the 3 major factors underlying it are context, omnipresence and optimization.

(Shaobo Li, Chen, Hu, & Hu, 2018) proposed an active sensing and processing of critical events framework (ASPIE) framework in IoMT (Internet of Manufacturing Things) based manufacturing. To meet and fulfill the conditions of real time monitoring in production plan execution, product quality inspection, manufacturing and material optimization and distribution through the application service layer, addresses the fact that accessing the perpetual information storage in different systems are used to optimize production process.

(Grewal, Roggeveen, & Nordfält, 2017) elaborate about the future of retailing by focusing on the emerging smart technologies like IoT, VR, AR, AI, drones, robots and driverless vehicles and also about above five areas that comprise the future of retailing: 1. Technology and tools to facilitate decision making, 2. Visual display and merchandise offer decisions, 3. Consumption and engagement, 4. Big data collection and usage, and 5. Analytics and profitability.
(Honeycutt, Solomon, 1987) talks about the major oil source along the Argentine coast and how it badly impacted seabirds across the coast. The oil spills and the discharges were very common, and it showed how badly it can affect the life of penguins. Basically, it is a big example of the limitations of the conventional methodology adopted for the process of oil extraction. With rising innovations and advents into Industry 4.0, many processes within the oil and gas industry have been subjected to a technological remap thus leading to higher effectiveness and less wastage of resources as well as improved concern for safety.

(Hoorens, Elixmann, Cave, Li and Cattaneo, 2012) talks about the key conditions which the European market was facing in the year 2012 and which technology will be the future for the industries. The authors also discussed about the key conditions, main drivers and the barriers impacting the growth and development of the industry. Some major factors identified by the authors include diffusion of cloud computing, growth of social networks, amount of data within an industry, mobility, increase of machine-to-machine (M2M) networks, availability of fast, reliable and reasonably priced internet connections, etc.

(Kennedy, 2014) talks about the importance and evolution of Internet of things in future. He also discusses the various factors affecting the adoption of internet of things. He also focuses on the IT security at a greater extent. The author also discussed on a lot of laws which affects the adoption of the technology of internet of things.

(Russo, Marsigalia, Evangelista, Palmaccio and Maggioni, 2015) talks about the scope of Internet of things in the contemporary companies, it also explores the regulations for the technology. According to the analysis the internet of things will create a dynamic network of billion and trillions of devices which will communicate over the internet and will lead to the development of the technology and subsequently lead to the development of the industry. The Internet of Things will bring tangible business benefits, such as the high-resolution management of assets and products, improved life-cycle management and better collaboration between enterprises.

(Raunio 2009) describes two distinct modes of communication within the IoT: thing-to-person and thing-to-thing communication. Thing-to-person and person-to-thing communications encompass a number of technologies and applications, wherein people interact with things and vice-versa, including remote access to objects on the part of humans, and objects that continuously report on their status, whereabouts and sensor data. Thing-to-thing communications involve technologies and applications wherein everyday objects and infrastructure interact with the human. Objects can monitor other objects, take corrective actions and notify or prompt humans as required. Consequently, the Internet of Things (IoT) is the networked connection of people, processes, data and things that together are able to achieve more relevant and valuable connections than ever before.

(Raunio, 2016) talks about the advent of Internet of Things (IoT) and how it has opened up a world full of interconnectivity. (Laplanche, 2016) talks about the implications of Internet of things in the healthcare industry. The authors also discussed how the traditional challenges can be overcome by the implementation of the technology.

(Magruk, 2016) through his paper highlights the various potential areas of Industry 4.0 and how future industries should react to this wave and adapt as soon as possible in order to have competitive advantage as well as attain sustainability. Several main factors affecting adoption of Industry 4.0 according to the author includes Results from prior usage of technology, having many processes within the industry, Competition, Possession of required skillset to manage and operate such technologies, and finally Globalisation.

(Pilloni, 2017) through his paper highlights how data will transform Industrial processes. The paper focuses on Internet of Things (IoT), Cyber-Physical Systems (CPS), crowdsensing, crowdsourcing, cloud computing and big data as key instruments of Industry 4.0. Some key factors to the adoption of such technology include improvements in: production efficiency,
quality and cost-effectiveness; workplace health and safety, as well as quality of working conditions; products’ quality and availability (Rghioui & Oumnad, 2018) in this paper talk about the challenges and opportunities of IoT in the Healthcare sector. The paper talks about the challenges faced by the Healthcare industry like the lack of adherence monitoring, Limited and prospected time, increasing complexity of devices connected, Security.

3. RESEARCH GAP AND METHODOLOGY
Extensive review of literature was done to explore the concepts of IoT, Industry 4.0 and digital readiness. But no specific study has been conducted in identifying the various stages of Digital readiness and how industries are evaluated on these lines. The study will take these factors along with additional inputs to come with a Digital readiness roadmap outlining various stages of readiness. The study also identifies the various drivers of Industrial IoT adoption among industries which help in extensively supporting decision making processes with respect to Industry targeting, evaluation and prospecting.

4. CONCEPTUAL FRAMEWORK
Conceptual framework refers to the framework created using the reviewed literature as to support the concept created from the studies.

Fig 1: Conceptual framework
Based on the analysis of reviewed literature, the conceptual and integrated model/framework developed is as shown above. In the conceptual model/framework, a complete overview of all the elements that contribute towards digital readiness have been illustrated. The model shows how each element is a core idea of digital readiness evaluation. The model also incorporates IIoT as one of the key elements and elaborates on the same by identifying and illustrating the
factors contributing to the adoption of IIoT in any industry. The governing fundamental entities in both aspects are represented in the model using the results from the findings. The above conceptual model is drawn with the aim of delivering maximum value to all those looking forward to adopting digitisation in the near future. The most important findings through this model is that the above findings are applicable for industries as well as independent companies as well, or even any individual concerned about a particular sector.

4.1 RESULTS AND DISCUSSIONS
After interviewing 20 industrial experts, their transcripts were used to derive key interpretations to the formulated objectives. The transcripts involved obtaining definitions to concepts and at the same time validating factors derived from various Journal papers.

4.2 To Analyze What Digital Readiness Means.

![Fig 3: Major responses collected from Industrial experts.](image)

There have been many models that have been developed around the idea of digital readiness. These models have even led to the development of digital readiness assessment tools. But even today the real underlying definition of digital readiness is not clear. While engaging with the industrial experts, each of them had their own notions about the idea. This brings about the need to understand what digital readiness actually is.

Based on the interaction, most of the industrial experts had the general explanation that Digital readiness is about having the capability to Capture data. Data is one of the most crucial aspects when it comes to any industry. Only 40% of the industries as of today even harness or collect data. Most of them just collect the same and don’t even interpret it, which makes the process a waste. But those who collect the data are still not aware of means to efficiently analyse it. Now, talking about another aspect that the industrial experts stressed on, the ease with which data is collected. This solely depends on the processes and the machines that the industries use. With
more number of machines, it becomes a difficult task to collect data and nevertheless differentiate the collected information from machine to machine.

Many industrial experts agreed on the common idea that it is not just solely about the data. Collecting data is a secondary step and would indeed one day be the defining state of digital readiness, but not as of now. Having any sort of digital initiatives in the industry which is being used as a hard-core part of their process and product lines could be a factor that establishes that an industry is digitally ready. But for that, we have to know what kinds of technologies qualify for the same. Even internet is a digital technology but does not qualify towards assessing an industries digital readiness.

So, there are some technological aspects that qualify to be under the purview of digital readiness for basic evaluation. Other industrial experts have spoken that to be digitally ready is not just about having technology, a lot of non-technical factors also come in the mix. Now this adds in more content towards the definition of the idea. If an industry has all the technologies, and its workforce is incapable of using them, so do you call it digitally ready? Based on collective analysis of answers given by the industrial experts, Digital readiness can be defined as “The ability of any industry to be well equipped in terms of Knowledge, Skill, technical-infrastructural capability and Trust in order to incorporate digital initiatives in their process lines and making the best use out of their resources”.

4.3 To evaluate the need for identifying the stages of Digital Readiness.

Now, this can be analysed from both aspects, the buyers side i.e. the customer side, and the seller side. As discussed in the previous objective, the general notion of what Digital readiness actually varies from industry to industry. But despite that, many industrial experts were able to relate to the idea and have proposed that it is indeed necessary to assess digital readiness.

Many industries have reached the saturation of their operations. For many industries, resources are scarce and depleting. Conventional means may prove to cause problems in the near future and hence there is a need to move towards digital initiatives. But industries as well as companies are often caught in the dilemma as to where to start, how to adopt and whether it is a good idea to even think in these lines. Many industrial experts claimed that moving towards digital initiatives even proved to be a wrong decision for many companies and hence adding the factor of risk into the mix. Hence it became important to analyse whether they are digitally ready or not. The parameters that qualify for these were also discussed extensively by the industrial experts, stating why the need from each factor. Industries that target digital initiatives are often large scale and have to face a lot of trouble on the move as their entire line of operations change. It becomes important to know where they stand in terms of digital readiness and assess their capabilities and use what is important to them and not just anything and everything.
A lot of industrial experts claim that data plays a major role. Yes, it does, but on a further stage. Industries that do not collect data can sometimes be digitally ready as well, based on their scale of operations and technical environment – two important factors that were contributed by the industrial experts.

4.4 To Evaluate the factors contributing to Digital Readiness and Segment them into various stages.

Several factors that contributed towards Digital Readiness were derived from various journals and showcased in the conceptual framework. In order to better understand the interpretation of these factors, they have been clubbed together into two themes. These themes are:

1. Technical Contributors to Digital Readiness Evaluation.

By clubbing these factors as such, the interpretation and analysis could be made accordingly and there can be a cross theme evaluation as to which theme must be stressed on and why. The questions for the interview process was also in such a manner that discussions around the technical contributors was initiated first with an assumption that they would first and foremost impact digital readiness. The following analysis would derive conclusions as to whether that assumption was right or wrong as well. Detailed technical questions were asked to 10 industrial experts about these factors and the results obtained were as showcased below.

Data constitutes the key to deriving any possible outcome or interpretation in the industry. All the Technologies that come under Industry 4.0 stress on having Data. So, this factor is justified and will be considered towards digital readiness. In addition to that Industry experts also stressed on the way in which data is collected and stressed on evaluating that also as a factor. But on further discussion it was proven that the type of data format will not impact digital readiness but the implementation of certain devices in the industry process lines.
Certain industries have information and communication technologies already running in their manufacturing lines and processes. Why industrial experts stress on this factor is that, if a company or industry has the same, then they already have a set up installation ready for data collection. Data collection being a preliminary stage can be furthermore stressed by having a central server that collects all the data. Information and communication technologies when set up in an industry often has a pre-setup which allows transmission of data across the industry. So, if data collection were to be implemented also, it would help data communication between people and machines as well. So, this factor can be considered towards digital readiness adoption as well.

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it comes to digital readiness. Many industries have adopted this technology in sync with many other Industry 4.0 technologies and giving promising results. The technology is still new but as per industrial experts, it qualifies as a technology that determines digital readiness. Indeed, if an industry possesses this technology and is using it efficiently, then it is much more than being qualified, it is already in the final stages of adoption. This brings the analysis to the final technical contributor, which is the most important factor as per industrial experts, Industry 4.0 awareness and adoption. If a company is aware about what industry 4.0 is and how it can actually transform their processes and derive suitable outcomes with savings alongside, then it has an interest to inculcate the same in its line of operations.

![Non-Technical Contributors](image_url)

Fig 5: Evaluation of Non-Technical Contributors to Digital Readiness

Now coming towards non-technical contributors, when asked about Industries Being Digitally Blind, Experts replied that being digitally blind is Level zero. The real task of assessing digital readiness should start with such a stage or factor that identifies industries as completely unaware of the technological advancements around and what can be implemented within them.

The answer for digital blindness did differ from person to person, but the overall idea remains the same, not aware of Technology initiatives, not having data for various processes, and zero Industry 4.0 awareness. Any and every kind of evaluation should start from this factor. Past digital experience should be considered, but not as a significant factor. Many industries may have adopted technology in the past, this marks them as digitally ready, but since they had a bad experience in the past they may refrain from such a move in future. But this is not the case always according to industrial experts and some defend that past digital experience is equally important. Tech adoption and its method have changed in the years. If it failed before, the chances of failing again are thin. More and more adoption techniques with used cases to prove them have emerged, giving companies the confidence, they always wanted to go for tech adoption. Hence, past digital experience qualifies for assessing digital readiness.

Based on the response from the Industry experts, having a workforce with technical experience qualifies as a contributor towards digital readiness assessment. Often it becomes a hard task for any industry to adopt technology because there would be resilience from the side of the workforce. It may take time to adopt to technological measures in the process lines, or sometimes workers fear technology would hamper their jobs and hence stand against the same.

Many industry experts stated that in the chemical industry this issue is minimal as the workforce is already equipped with technology and training them in new innovative measures would not be a hard task. But in other industries like OEMs, where tech is subtle, workers may have a hard task shifting towards tech adoption. Hence, if an industry has a workforce that is ready to
adopt technology, then it would be easy to adopt technology, and hence considered for Assessing digital readiness. Competition is a generic factor. Any and every industry competes with the other and looks for factors to stay ahead. It is a generic factor and should not be considered as a contributor to assess digital readiness in any industry.

During the interview with industry experts, they highlighted that Infrastructure and technical environment should be considered as two separate factors and not one. If an industry has a good infrastructure, then it may have sufficient processes that promotes the idea of digitization. Having a technical environment means already having any sort of predefined network or data channel within the industry that will help the idea of digitization easy and is given more weightage in the domain of digital readiness assessment. Based on the analysis of both Technical and non-technical contributors, the stages of Digital readiness derived were as follows. As discussed, being digitally blind constitutes a level 0, followed by having a large industry infrastructure. Technical environment was derived as the next stage which leads to analysing whether the environment so said possesses ICT equipment and if so whether it is a part of the industries past digital experience.

These 4 stages contribute towards the preliminary stages for identifying digital readiness, and once any industry qualifies for the same, the following stages are evaluated. The industry should have data being collected with the help of sensors. Having a tech capable workforce is the next necessary criterion followed by the main players, Industry 4.0 awareness, and IIoT cloud and AI adoption. Once a company achieves all these stages then it is in the forefront of technology. The model also gives room for future anticipation derived from the journal stating that there will come a stage when the entire system is monitored via cameras and even the slightest event both machine and human is detected and fixed immediately. Voice operated machines is like a dream that is soon to be seen in action in industries by the year 2030. The model identifies that adoption of IIoT for any industry stands as the one of the final stages in assessing digital readiness in industries. In order to be digitally advanced and ahead, industry must possess IIoT and all the other factors or stages preceding will automatically fall into place. Hence it became important to analyze the drivers affecting Industrial IoT adoption as well.

Fig 6: Stages of Digital Readiness
4.5 To understand the need and requirement of Industrial IoT in the industrial space

The very foundation for any industry to adopt any sort of technology is to understand whether there is any underlying need or requirement for the same. When it comes to knowing the need for Industrial IoT, the process becomes more stringent as the concept is new and still not widespread in the industry. According to Industrial experts, this can be addressed on many ways. Since the innovation is. Pretty new, companies offering Industrial IoT solutions have to generate a need within many industries. In order to efficiently do the same, it becomes very important to make the customers aware of Industrial IoT and other Industry 4.0 technologies. General awareness about these technologies should be passed on by showing how these technologies are rapidly being used in many other industries and how the impact has been. This can be further promoted with the help of company used cases.

When it comes to Oil and gas as an industry, generating a need becomes more prominent, as most of the companies still utilise conventional means and find it the best means of operation. There are many processes within oil and gas that can be subjected to Industrial IoT, ranging from upstream, midstream to downstream. Those companies incorporating Industrial IoT in their operations, employ them in a selected array of processes, that do not often lead to making the best out of IIoT potential. Hence need generation plays a role there too.

Oil and gas is a sector where Industrial IoT is being used in abundance. But the percentage of still has not crossed 30%. IIoT companies like Flutura target Oil and Gas companies and convey the idea of digitisation and give them statistics as to how their processes will change and how

Fig 7: Major Responses collected from Industrial Experts
much projected savings can be derived. Also, it becomes important to point out the most optimum utilisation of resources, as oil is a depleting product and as of now scarcely available. By outlining factors addressing key issues, a need can be generated in industries that have a low adoption rate for technology adoption. Before analysing need it becomes important to evaluate whether industries are digitally ready as well.

When it comes to chemical industries, the context is different, according to industrial experts. The chemical industry, unlike Oil and Gas, is far ahead in terms of tech adoption and they understand the need for having industrial IoT in their line of operations and the impact it can create in terms of Yield, energy efficiency and time management. So, in this case it is more of requirement. The work that has to be done by IIoT companies is pretty much less as the industry more qualifies to be digitally ready.

There are many such industries that are still potential prospects for tech adoption and have to be segregated well and understand whether to cater to a need or requirement. Understanding this will lead to evaluating and emphasising companies towards IIoT adoption by demarcating factors affecting the same.

4.6 To Understand and Evaluate the various Drivers of Industrial IoT

When it comes to industrial IoT adoption, there are many key parameters that influence them. It becomes important to analyse them and find out which factor would influence which industry more. In order to outline major contributors towards the same, information from various Journal papers were used to derive a preliminary set of drivers. In order to effectively analyse the factors outlined in the conceptual framework, they were divided into two themes:

1. Technical Drivers of Industrial IoT adoption
2. Non-Technical Drivers of Industrial IoT adoption

By doing so, a structure was achieved, and it became easier to interpret responses generated from the industrial experts. Responses were then clubbed together to identify common angles ascertaining whether the factors contributed or not, based on industry experience. Detailed Technical questions were framed in a discussion format and asked to 10 industrial experts, leading to the following results as showcased below:

![Fig 8: Evaluation of Technical drivers of Industrial IoT Adoption](image)

Data is the first and foremost necessity when it comes to Industrial IoT adoption. Almost all the industry experts agreed on the fact that data constitutes the most essential aspect of tech adoption in any industry. It is only through data that interpretations regarding operations and
key decisions impacting the same can be taken. 5 major observations that stood as a basis for this understanding are as follows:

For any industrial IoT service being offered, Data is very prominent, so is the form of data that is being collected. Sensors are mounted on all the machines in the process lines, collecting data and sending the same to a central server.

As per industrial experts, the format of the data captured becomes important when data accuracy is considered. Event-based data capturing is much weaker compared to time-series data and hence must be considered as a factor when data possession and accuracy is considered.

Most importantly, companies must be aware about Industry 4.0 and how it is being predominantly used in various companies of varying processes. If a company is aware about the technology practices and how it benefits, then there is a more chance that they will be inclined towards adopting the same. Industrial experts highlighted the fact that for any company, it need not be necessary for a majority of the company to be aware of Industry 4.0. The focus should be on the decision makers and influencers like CEO and CTO. As per one industrial expert, he stressed that companies inclined towards tech adoption and using innovative and advanced technologies in their line of processes have paved way to a new post called Chief Disruptor officer (CDO). The advent of Industry 4.0 has indeed affected not only how a company operates, but how a company thinks as well, and hence as per the experts, Industry 4.0 awareness more than qualifies for being an IIoT adoption factor.

Industries like Oil and Gas employ huge machines in their processes which have a high level of investment involved. Same goes for many machines/assets in chemical industry and OEMs. Asset health tracking and optimum utilisation of assets is one primary outcome of employing IIoT solutions in industries. The more sensors one uses in a machine, the more accurate the data will be. This was better explained by an industrial expert by stating a case from the oil and gas industry. Constructing a well takes years for Oil extraction, and companies would like to derive the most out of the same. Before IIoT came into the picture, companies used conventional means to identify well integrity based on constructional parameters and estimated life to be around 8-9 years, after which the well is let idle. But after employing IIoT solutions, exact measures of well integrity and solutions to increase well life are computed with the help of machine learning and data analytics.
of the interpretations derived along with AI. With these interpretations now in the picture, a
well was used for 3 more years than estimated life, thus saving over 400 million dollars for
companies as they don’t have to invest in constructing a new well suddenly.
Experts had a varying approach towards tech maturity and stated that it did not add much value
towards IIoT adoption. Most companies are for a fact not technological mature, and hence a
need is generated among them. It is more of an implied factor and should not be stressed on
much.
Now coming towards energy efficiency. Large scale companies see energy efficiency as a
reason to adopt technology, but not a primary reason, as the projected savings from energy
efficiency is not too much, as per an industrial expert. Moreover, companies have a notion or
belief that through energy savings, the quality of production and yield may be affected and will
think otherwise only when there is substantiating data to prove the same. Hence it can be
considered as a key factor, but not that predominant.
Time management is another driver that is a derivative connected to energy efficiency. The less
time your processes take, the less energy is consumed. This factor depends on the industry of
impact. For instance, it is not a crucial factor when in the Oil and Gas industry, but in the
chemical industry, the end product is consumer driven, like adhesives and paint and is not too
much abundant in the market. Adding to that, some experts claimed that time management
should not be a factor stating that many chemical processes require a lot of settling time in
between, and as a result of the same, my compromise with the overall quality and yield of the
product. Employing Industrial IoT solutions helps in establishing interconnectivity between
machines to machines, machines to people, as well as people to people. But experts claim that
it is not that important a factor as not all the processes in an industry require this. If there is an
AI driven platform working back end and it is given permission to make decisions on its own,
then having interconnected assets makes sense. Companies still feel that having IIoT solutions
is necessary, but only to give insights and interpretations to the person handling the operations.
Even though AI plays a major role, it has not been given full access to process line operations
and manual intervention is always stressed by companies. As a result, Interconnectivity does
not hold much prominence as factor, based on industrial experience.
Coming towards a major influencing factor, the workforce. Industrial experts had varying
opinions based on their specific industrial experience. In companies working on conventional
means and lying in the lower stages of digital readiness and tech maturity workforce becomes
very crucial, as they would be against the idea of digital adoption. Adopting technology would
lead to many job roles being affected and hence creates a problem. One industrial expert
clarified this further with an example from the oil and gas industry. Before tech adoption, well
inspection was done by several employees by going on a daily route to individually inspect
each well. With the inclusion of Industry 4.0 technologies, assets were able to be monitored
remotely, thus eliminating the need for such a job/practice.
But this is not the case when it comes to the chemical industry. The workforce in the chemical
industry knows and understand the importance of having technological adoption as the industry
is way more tech mature compared to other industries. They already have processes
incorporating technologies and evaluate them based on what additional value they are
benefitted with, like less human intervention, safety regulations, higher yield and productivity,
etc. If an industry has a workforce that already possesses the skill in operating technological
processes, then it leads to high levels of tech diffusion. Based on the responses from the
industrial experts, present workforce does qualify as a factor for Industrial IoT adoption but
has to be considered in close consideration with other industry factors like type of industry and
Industry 4.0 awareness.
There are many Non-technical drivers that influence adoption of Industrial IoT. When NonTechnical factors are brought into the picture, the first aspect that crops up is revenue. This can be looked in from two angles, revenue spent to acquire the technology as well as revenue saved as a result of having these technologies. But even though it is a well sought to factor, it need not be the case all the time. Many Chemical companies do not look at revenue when it comes to adopting such technology as their key motive is to have improved quality and yield with high levels of accuracy in the final output.

This was further explained by an industrial expert where he stressed that chemical companies often produce machine critical goods like adhesives for the aviation industry (aircrafts) and that their final output or products USP was a derivative of using such technological aspects. But in certain Oil and gas companies, revenue becomes a very challenging aspect each and every penny counts. Even though most of the companies have high sources of revenue, they still think twice before shelling out huge loads of money, as oil and gas is capital intensive in nature, and quality does not play that much as a role as it does in the chemical industry. So, in a way, revenue does qualify as the most basic Non-technical evaluating factor in IIoT adoption.

Another aspect is competition. Any and every industry faces competition, but that does not always have to be an underlying factor for tech adoption. As per experts there are many companies within the Oil and gas that are way ahead in terms of other companies that have incorporated technological advancements. It is not about just having them but having the right means and expertise and effective utilisation of the same as well. Often competition is seen to be interlinked with the idea of early adoption. Yes, early adoption does make a difference, but it’s a bit risky as well. Many chemical and Oil and gas companies that have been early adopters. Have understood the best use of technology to have seamless operations within their process lines. They will always be one step ahead as well, to the other firms in terms of operations, savings and quality of output.

There is no doubt, almost all industrial experts agreed on the fact that Quality and yield improvement is the most influencing Non-technical parameter and its. Importance has been stressed in many contexts. Mainly for industries like the chemical industry, where the quality of the final product can lead to major outcomes, this factor becomes very important. Yield is yet another associated factor and is prominent in every industry.
With the inclusion of industry 4.0 and IIoT technologies, one main objective of fulfilment is reduced human intervention. This is not just to make sure that the process happens with utmost accuracy and decreasing error rates. More stress on tech adoption was given due to the alarming conditions humans go through in such industries. In the oil and gas industry, there exists many areas where human intervention can prove to be fatal. Same case for any other industry as well. Safety regulations over the years has become very important and keen and even made compulsory by authorities in charge. But regulations do not contribute as much to industrial IoT adoption as much as safety does. The final aspect that was discussed was companies thinking on the lines of sustainability. But the factor did not contribute much towards tech adoption as of now, as companies in this space are not keen towards sustainability as a crucial factor for tech adoption.

5. FINDINGS
From the statistics obtained, the following inferences were made:

1. Being Digitally blind was found as the basic stage for evaluating digital readiness.
2. Past Digital experience is another major factor that contributes to companies being Digitally Ready.
3. It was identified that workforce diffusion of technology is important for an industry having huge human resources employed in its operations and processes.
4. Competition as a factor as discarded by many industrial experts.
5. Data Collection is a prominent necessity when it comes to being digitally ready.
6. An industry having ICT equipments already installed gives it an edge when it comes to digitisation.
7. Having M2M, P2M, P2P systems did not turn out to be a prominent factor to the necessity of industrial digitisation.
8. Most of the industrial experts discarded semantic web as a factor.
9. Industry 4.0 awareness turned out to be one of the most important drivers when it comes to Digital Readiness.
10. Both infrastructure and technical environment qualify as a stage for digital readiness evaluation, with many experts differentiating the two through the discussion.
11. Most of the Industrial experts identified IoT adoption as a final stage of digital readiness in the present.
12. Possession of Data and data accuracy were found as contributing towards industrial IoT adoption.
13. The format of data was identified as an additional factor which was not mentioned in the research papers discussed.
14. Industry 4.0 awareness was stressed as a contributing factor
15. Focus on equipments and increase in equipment life highly qualified as a contributor to Industrial IoT adoption.
16. Low ratings were given to assessing tech maturity, hence will not be carried forward as a driver.
17. Energy Efficiency is highly perceived in the industry and is seen as a contributing factor.

18. Even though there was stress on time management as a factor, explanations derived from responses prove that it is a derived aspect and need not be considered as a primary factor.
19. Interconnectivity mostly not considered a an IIoT adoption driver as the need for interconnectivity has not been much identified in the industry.
20. The adaptability of the workforce in terms of skill level as well as technical diffusion among them generated 60% positive response. Since the experts that highlighted on it as a positive driver explained how it impacts in detail, it qualifies as a major driver.

21. Revenue and competition are obvious Non-technical factors that are always considered towards adopting any sort of industry 4.0 technologies.

22. Early adoption is a key strategic advantage according to the experts and can be considered as a non-technical contributor, but the significance is average.

23. Quality and yield improvement top the ratings in terms of drivers among all industrial experts and is the main contributing driver.

24. Reduction in Human Intervention acts as a primary Driver to Industrial IoT adoption, which leads to an additional factor – decreased error rates in processes.

25. Customer satisfaction did not qualify as a driver of Industrial IoT adoption.

26. Safety is highlighted as another key driver of Industrial IoT adoption due to importance of human life as well as the added impact of regulations.

27. Regulations do not qualify as a factor for IIoT adoption.

28. Sustainability as per experts is not a primary factor for IIoT adoption as of now, but in 2-3 years will be considered as a key driver.

29. Suggested integrated model framework for adoption of IIOT was developed as follows based on the insights garnered from this study.

Fig 11: Modified Conceptual Framework
6. CONCLUSION
Several studies have been conducted regarding Industrial IoT, Industry 4.0 but there have never been studies relating to the digital readiness of industries and how they have to be evaluated in order to understand industry position in terms of digitisation. In addition, the study also highlights the major drivers of adopting industrial IoT as it was identified as the last stage of digitisation among prominent industries. This paper presents digital readiness stages, which can be used by companies to evaluate where they stand and can be used by technology providers to assess need of the consumer and deliver services accordingly. with customer centric approach. Using the above findings, the companies will be able to prepare in advance towards the dynamic changing requirements of customers and market itself and hence achieve sustainable competitive advantage as well. Furthermore, the conceptual model framework constructed can be used in isolation as well as in integration. The model constructed is not limited to any specific zone or region and is applicable across every region.

7. REFERENCES


