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The Future of Industrial Internet of Things (IIoT) after COVID19 Pandemic

Rituraj Patil
Master of Management Studies
A. C. Patil College of Engineering and Management, Kharghar, Navi Mumbai, MH, India

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ABSTRACT

Industrial IoT (IIoT) devices obtain, analyse, and use data from connected equipment, Operational Technology (OT), locations, and people. IIoT helps to regulate and monitor industrial systems. Also, the same implementation can be carried out for automated record updates of asset placement in industrial storage units. IIoT can realize the seamless integration of various manufacturing devices equipped with sensing, identification, processing, communication, actuation, and networking capabilities. Based on such a highly integrated smart cyber-physical space, it opens the door to create whole new business and market opportunities for manufacturing. Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IIoT within the realm of industrial applications and smart manufacturing as well. IIoT in manufacturing could generate so much business value that it will eventually lead to the Fifth Industrial Revolution, also referred to as Industry 5.0. Though IIoT is getting widely explored and used by many global organizations, especially with the current COVID19 Pandemic situation. The global industry moves to address these concerns have begun including the development of international standards. This study examines the prospects of Industrial IoT and its application in the global business sectors for doing their businesses more effectively and efficiently. This study would assess the most suitable IIoT models of various IIoT services offerings industries will likely use. The study will also analyse risks and challenges for the global business entities, while adopting IIoT technologies and service offerings along with their actual needs, wants, desires, suitability, requirements, and expectations.

Corresponding Author:

Rituraj Patil,
Master of Management Studies,
A. C. Patil College of Engineering and Management,
Kharghar, Navi Mumbai, MH, India
Email: rtpatil@acpce.ac.in

1. INTRODUCTION

The Internet of things (IoT) describes the network of physical objects, things that are embedded with the sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation, and others all contribute to enabling the Internet of Things. In the overall context of global

consumer market and industries, the IoT Technology is most synonymous with products pertaining to devices and appliances that support one or more common ecosystems and can be controlled via devices associated with that ecosystem.

Industrial IoT (IIoT) devices acquire and analyse the data from connected equipment, Operational Technology (OT), locations and people. IIoT helps to regulate and monitor industrial systems. Also, the same implementation can be carried out for automated record updates of asset placement in industrial storage units. IIoT can realize the seamless integration of various manufacturing devices equipped with sensing, identification, processing, communication, actuation, and networking capabilities. Based on such a highly integrated smart cyber-physical space, it opens the door to create whole new business and market opportunities for manufacturing. Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IIoT within the realm of industrial applications and smart manufacturing as well.

The IIoT based intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors, and control systems together. Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IIoT. It also extends itself to asset management via conditional monitoring, predictive maintenance, statistical evaluation, and measurements to maximize reliability. Industrial management systems can also be integrated with smart grids, enabling real-time energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by many networked sensors.

IIoT in manufacturing domain could generate so much business value that it will eventually lead to the Fifth Industrial Revolution, also referred to as Industry 5.0. Though IIoT is getting widely explored and used by many global organizations, there are several serious concerns about the vulnerabilities in the growth of IIoT, especially with the current COVID19 Pandemic situation and in the areas of privacy and security. The industry and governmental moves to address these concerns have begun including the development of international standards.

This study examines the prospects of Industrial IoT and its application in the global business sectors for doing their businesses more effectively. The study would assess the most suitable IIoT models (like Subscription, Outcome-Based, Asset-Sharing, Razor Blade, IoT Data Monetization, Pay-Per-Usage, and Offer a Service) of various IIoT service offerings industries will likely use. Further, the study also analyses the risks and challenges for the global business entities, while adopting IIoT technologies and services offerings along with their actual needs, wants, desires, suitability, requirements, and expectations. This study focuses on understanding the potential impact of current COVID19 Pandemic on the advanced IIoT Solutions within the global enterprises and setting the overall context of the current state by looking at the various considerations for most of the adoption and solutioning possibilities in near future.

This present study on "The Future of Industrial Internet of Things (IIoT) after COVID19 Pandemic" has following major objectives:

1. Appraisal of the strengths and limitations of the Global IIoT market for global enterprises.
2. Identification of the products / services / solution offerings portfolio of IIoT, which are in demand for Global Enterprises by adapting software and technology solutions.
3. The assessment of business opportunities offered by the IIoT to global enterprises and competitive advantage to the consumers and end-users of IIoT of those global enterprises.
4. To analyse the impact of the current COVID19 Pandemic on various business models available in IIoT for global enterprises that will be suitable and competitive in terms of cost, business expansion, profit, security, and overall resource management.
5. To identify suitable strategic business model for the global enterprises to compete effectively and management of resources to take advantage of new IIoT environment after the current COVID19 pandemic.
6. To assess the various risks and challenges of IIoT Technology adapted at global enterprises after the current COVID19 pandemic and to identify various ways to address them.

2. RESEARCH METHOD

Global enterprises are flocking to the new IIoT products, services, and solution offerings, which provide secure IT infrastructure with little up-front investment and no heavy infrastructure. For the global enterprises making use of IIoT based automation solutions by themselves, rather than using equivalent manual services, the return on invested capital will eventually grow by cost savings and they will be able to match the rapid development of their business needs after the current COVID19 Pandemic. The basic advantage of IIoT based service offerings will be direct cost reduction and an increased business performance, agility along with an overall improvement in the IT performance.

Global Enterprises and their associated Economics have got heavily impacted by the current COVID19 Pandemic. Still, they are making tremendous progress in Services, Products, Retail, IT, Infrastructure, Banking and Finance, Insurance, Processing, Automobile, Pharmaceuticals, Engineering, and Manufacturing, etc. sectors. As a result, global enterprises are getting more and more opportunities to enhance their activities by expanding and diversifying their businesses in the core sectors using some of the advanced Industry 4.0 oriented technologies such as Industrial IoT, Cloud Computing, Artificial Intelligence, Machine Learning, Data Analytics, and many more. The following table shows the overall impact of COVID19 Pandemic on Global Economies.

Table 1. COVID19 Pandemic Global Economy Impact Outlook - World Bank, June 2020

Global Economies by Countries	2019 GDP	2020 GDP	2021 Projected GDP
United States	2.3	-6.1	4.0
Euro Area	1.2	-9.1	4.5
Japan	0.7	-6.1	2.5
China	6.1	1.0	6.9
Indonesia	5.0	0.0	4.8
Thailand	2.4	-5.0	4.1
Russia	1.3	-6.0	2.7
Turkey	0.9	-3.8	5.0
Poland	4.1	-4.2	2.8
Brazil	1.1	-8.0	2.2
Mexico	-0.3	-7.5	3.0
Argentina	-2.2	-7.3	2.1
Saudi Arabia	0.3	-3.8	2.5
Iran	-8.2	-5.3	2.1
Egypt	5.6	3.0	2.1
India	4.2	-3.2	3.1
Pakistan	1.9	-2.6	-0.2
Bangladesh	8.2	1.6	1.0
Nigeria	2.2	-3.2	1.7
South Africa	0.2	-7.1	2.9
Angola	-0.9	-4.0	3.1

Faced with the COVID-19 crisis, the industrial leaders have one business imperative: maintaining their operations. IIoT, implemented in a plug-and-play mode, can be instrumental in ensuring business continuity and minimizing economic damage by ensuring employee safety and security, improving liquidity, and lowering short-term costs. Global Industrial Enterprises expected 2020 to bring economic pressure from ongoing trade disputes, the aftermath of Brexit, automotive-industry challenges, and slowing demand in China. But none anticipated that the COVID19 Pandemic would throw the global economy, their own operations, and some other associated entities into an unprecedented crisis. As the coronavirus continues to spread, governments, healthcare authorities, and business leaders are focused on preserving lives and containing the pandemic. In parallel, they want to lessen the humanitarian toll by protecting the livelihoods of millions of global workers who are now furloughed, unemployed, or in danger of losing their jobs.

Industrial IoT (IIoT), a major element of Industry 4.0, can help companies as they proceed on this journey. It has demonstrated its value on many occasions over the past few years, but some sceptics still doubt its worth and elected not to make bold investments in this area. What is more, few business leaders view IIoT as a critical improvement lever in times of crisis, especially if their organizations have not previously explored it. Within industrials, shocks to both supply and demand have significantly decreased production volumes or stopped operations. For instance, all major automotive OEMs in Europe have shut down their production networks, resulting in the breakdown of entire value chains. Where business has continued, physical-distancing measures are dramatically altering operations, employee responsibilities, and staffing.

Companies are suddenly dealing with remote work on a large scale, as well as new concerns about protecting their remaining on-site employees, and have adapted their workforce organization in consequence. In general, the more digitized a company’s processes are, the simpler it is to collaborate remotely. Off-the-shelf IIoT tools support the continuation of operations with fewer employees on site since they facilitate remote work in direct and indirect functions. For example, a US tier-one supplier is using a manufacturing-execution system (MES) to optimize production and increase transparency. Even though many managers are no longer on site, the MES outputs provide the information they need to have valuable discussions during videoconferences. Similar solutions are available for the shop floor. Consider how one European commercial-vehicle OEM uses digital team boards to coordinate jobs, measure production levels, and

improve performance gaps across shifts. Other IIoT tools, such as digital heat maps, can supp rt root-cause analyses for various problems. With machine breakdowns, for instance, IIoT tools can receive input from sensors that help pinpoint problems, such as broken components or oil leakage that could interfere with production.

When facilities remain open, workforce-tracking solutions can help enforce essential physical-distancing measures. If workers consent and local regulations permit, employees can wear positioning devices for fencing purposes that show where they are moving within a facility. This information gets fed into intelligent algorithms that help managers optimize workflows and minimize contact at shift changeovers and other critical points. One of the companies quickly staggered breaks and rearranged shifts based on IIoT insights, allowing it to continue operations while drastically reducing employee contact. Some IIoT tracking solutions automatically restrict access to certain areas if there are too many people. If employees test positive for the coronavirus, companies could use positioning data from their wearable devices to notify colleagues with whom they had been in proximity. All worker-specific information must be anonymized to protect employee privacy. And if COVID19 forces many people to be absent because of illness, the devices will inform management about short-staffed areas, allowing management to identify operational areas where slowdowns or other risks may materialize.

To navigate current crisis and reach next normal after the pandemic abates, companies must embark on a journey with three horizons, each of which involves following different themes-based questions:

1. Resolve. How can we ensure business continuity?
2. Return and resilience. How can we return to business and increase our flexibility to thrive in the "new normal"?
3. Reimagination and reform. How can we improve our business over the long term, in a world changed by the pandemic, and emerge even stronger?

Table 2. Coronavirus: Industrial IoT in challenging times - McKinsey Insights, April 2020

Theme	Target	IIoT Use-Case Example	Full Potential
Resolve	Ensuring employee safety and security	Remote employee collaboration, Vision-based control systems, and Remote asset control	Safeguarding Operations
	Improving liquidity	IIoT enabled inventory management	-10% to -35% inventory
		Waste reduction	-20% waste
		Maintenance cycle increase	-10% to -15% maintenance
	Lowering costs in short term	Digital performance management	
Return and resilience	Remote assistance	Large-scale connectivity	Strategic enabler
	Connectivity and cyber security	Cyber security	
	Mid-term cost flexibility	Asset optimization	Up to 5% equipment effectiveness
		Real time procurement transparency	
	Revenue stability	Next best action for sales and service	Case dependent
		Dynamic pricing optimization	
Reimagination and reform	Increasing operational flexibility	Supply chain integration across	Strategic enabler

As with remote-collaboration tools, vision-based control systems can play an increasingly important role during the current crisis. For instance, systems that analyse video feeds can be combined with infrared imaging to detect fevers. Together, these tools can assist with the identification of infected or infectious employees, monitor physical distancing, and ensure that sick employees remain home. Some companies combine low-tech measures with vision-based control systems for the same purposes. Amazon, for example, takes body temperatures of workers at the entrances to warehouses. It also uses machine-learning software to analyse footage from on-site video cameras to ensure that employees are maintaining safe, recommended distances from one another during shifts. IIoT can allow companies to maintain operations when public-health interventions forbid or limit on-site work by monitoring and controlling equipment remotely. To implement such services, companies must connect critical assets to cloud-based control software. Machinery OEMs and vendors of industrial control software offer connectivity kits and software extensions for most equipment. Employees can then establish access to these tools from home while adhering to the highest security standards to protect their companies and customers.

IIoT-enabled inventory management can help industrial companies reduce inventory and thus directly free up liquidity. For instance, sensors can monitor container-fill levels at a single site using ultrasound. Other applications can track the flow of materials over long distances by using geo tags in combination with integrated mobile communication. This real-time transparency allows the logistics team to manage the material flow more accurately and order raw materials and other inputs closer to the date they are needed, reducing inventory. Although results vary by industry and company, IIoT can help reduce overall inventory levels by up to 36 percent.

Like inventory management and operations, IIoT can provide transparency about the waste created during the production and its root cause. These insights help save cash because less raw material is needed to produce the same quantity. For mass production, companies can achieve significant savings by installing basic measurement devices, such as scales and in-line sensors that send information via IIoT. For example, a packaging company started to measure the length and weight of the plastic film thrown away and began to incentivize machine operators to reduce waste. These efforts helped reduce waste by 20 percent in under six months. Instead of replacing a machine part after a certain time, companies can extend its lifetime by measuring its condition with IIoT sensors. If a repair is not warranted, companies can delay it beyond the standard period. Improved conditional monitoring and its associated services and service offerings typically reduce the overall running/ maintenance costs by almost 10 to 15 percent. Companies can think about its long-term promising benefits.

IIoT-based software solutions can provide a real-time dashboard of key performance indicators to support shop-floor performance dialogs, increasing transparency. These tools allow the tracking of improvement actions and send alerts to operators via mobile devices. The software evaluates machine data, such as information on overall equipment effectiveness, part production, and quality through IIoT connectivity. Improved performance can help companies boost labor productivity by 20% to 40%.
In addition to improving employee safety, experience suggests that remote assistance and maintenance tools can yield a 10 to 40 percent reduction in field-service costs, especially travel, by reducing the need for in-person visits.

The gains may be particularly high at machinery OEMs with a large installed base. Many companies have a pressing need to provide employees with remote access and control of various machines. Since many machines are now experiencing higher-than-usual downtime, companies may be able to install connectivity kits on them more easily. To accelerate the rollout, workers could install a connectivity box each time they perform routine maintenance services. Every machine that is connected to the internet will help industrials, since it becomes available for remote monitoring, data collection, and other services. As companies increasingly digitize their manufacturing operations, cybersecurity becomes more important. As with large-scale connectivity, companies can more easily improve cybersecurity at all levels when asset downtime is high or operations are shut down, since applying fixes will not create major disruptions.

Companies can undertake some simple cybersecurity measures, such as critical software updates and firmware updates of hardware, quickly. These small steps help to minimize overall cybersecurity risks. IIoT-enabled asset optimization involves using advanced analytics to identify the root causes and countermeasures related to the three drivers of overall equipment effectiveness (OEE): availability, performance, and quality. For instance, an aerospace supplier had a low OEE when producing an important airplane component. It then used IIoT solutions to monitor and detect certain problems, such as tool wear and missing materials. Based on this sensor information, the company was able to optimize job sequences in a central control room. With these improvements, the company achieved 80 percent OEE. IIoT tools may also help companies discover previously unknown problems within the supply chain. While impact may vary drastically across settings, companies may improve OEE by as much as five percentage points, for example in low-volume, high complexity discrete manufacturing settings.

IIoT tools can help companies optimize procurement by using real-time information on inventory levels and production capacity to determine what quantities must be ordered and assist with rapid contract renegotiations. This feature is relevant during the current crisis because commodity prices have decreased significantly. Take oil and copper, both of which have decreased in price by about 20 to 25 percent. Optimizing vendor allocations and improving negotiation strategies typically deliver a 2 to 5 percent reduction in raw-material costs. Given current events, these savings will likely be higher now. This customer-centric use case can increase both revenue and customer satisfaction. Applying advanced analytics to installed base management, companies determine the best actions for sales and service to take next with a particular customer after assessing data about its current machines. Depending on local regulations, such data could include information on real-time and historic machine conditions, as well as customer records. The relevant IIoT tools can also estimate how customers might respond when they encounter certain service issues or are offered various options, such as service upgrades or the supply of spare parts or consumables.

The revenue impact of this use case varies significantly by industry, depending largely on the importance of after-sales services. Companies can also apply this use case internally to define the next best action for their own maintenance team, provided that the necessary data are available. IIoT-enabled pricing tools can analyse data on supply and demand from connected assets in near-real or real time, including information on stock levels, available capacity, production schedules, and anticipated delivery dates. Based on this analysis, the tools recommend the best price for a particular date, allowing companies to make updates more frequently. This use case typically increases revenues by up to 5 to 8 percent. It also allows companies to simplify pricing frameworks for new products. IIoT facilitates real-time data exchange between all supply-chain participants, creating an integrated view of production programs, scheduling, inventories, quality, and anticipated delivery times. In addition to building transparency and trust, such tools can also reduce supply-chain costs and risks. With these insights, companies can optimize inventory levels, production planning, and transport utilization through a more holistic approach. Companies will also learn about supply-chain problems more rapidly, allowing them to act before they escalate.

IIoT can increase production efficiency of single machines or entire production lines by using advanced analytics to optimize process parameters. The algorithm analyses information. Data from individual machines get combined with information about the overall production program, allowing companies to optimize machine settings based on previous and subsequent production steps. It is difficult to accurately predict the social and economic impact of COVID19 pandemic on IIoT market at global level, but by combining economic scenarios with datasets and prior experience, we can assess its impact on the engineering, manufacturing, and industrial software markets in general, and Industrial Internet of Things in particular. In the short-term to medium-term, the predicted impact on different industries is not uniform. In general, those industries that depend on disposable income, such as those that are travel-related or fashion-related, will be affected more than those that are crucial, such as utilities and medically related industries. The following graph shows Cambashi's (a global market research, industry analysis, consulting & training firm, focused on engineering and industrial software markets) analysis of the connected applications in IIoT market shows that the growth during the last few years has been very positive, and the effect of COVID19 is likely to be for some time ahead. The overall growth is remaining stable for all market areas through the pandemic till the end of 2022 and then picking up again in 2023. Market areas are affected positively or negatively because the connected applications are affected in different ways by the market drivers above. This allows us to identify in some detail, the potential winners, and losers in the IIoT market.

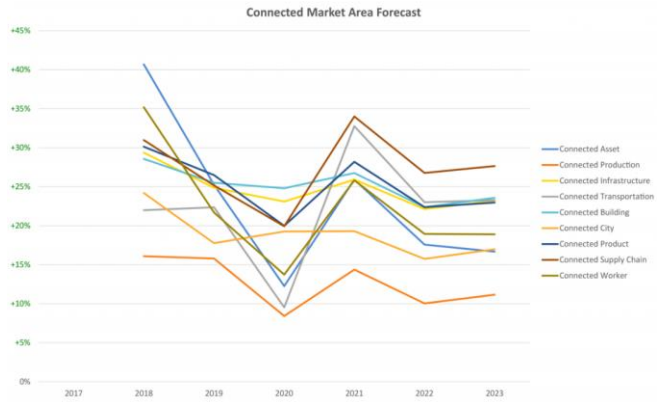


Figure 1. Impact of COVID19 on the Connected Applications Software / IIoT Global Market (provisional figures) - Cambashi / Connected World, July 2020

Other major variations can be explained by the following market drivers:

1. Reshoring due to the fragility of global supply chains, leading to increased investment in industrial automation software.
2. Increased investment in proven applications that have short-term payback.
3. Reduced investment in exotic applications that are harder to justify.
4. The negative affect of financial and societal factors on certain industries.
5. The proximity and safety specific measures enforced by the crisis.
6. The growth of cloud-based applications as used to manage business disruption.
7. Winners and Losers - The Impact on IIoT / Connected Applications and Digital Transformation.

Conditional Monitoring and Predictive Maintenance are the constituents of IIoT delivering business value in several market areas, whereas some more ambitious applications are experiencing funding issues. Business solutions require transformation programs as well as application software and an ecosystem of providers. The below matrix shows where the combination of Technological Capability and Business Impact is likely to be successful in these times of COVID19 Pandemic.

The ecosystem of providers required to deliver ranges from management consultant on the top layer, to systems integrators in the middle, and technology providers at the base and all involved at all levels. Conditional monitoring is the process of monitoring a parameter of condition in machinery, where IIoT based solutions can be used to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. With conditional monitoring based IIoT solutions, manufacturers can prevent damage and reduce maintenance costs: Sensors track changes in vibration, temperature, and output to detect any issues with corrosion, wear, misalignment, imbalance, or lubrication. IoT-based predictive maintenance enables more efficient use of existing assets by providing the ability to predict machine failures and reduce maintenance issues. It can help identify the causes of delays, whether they're internal or external, and help set up processes to address these causes.

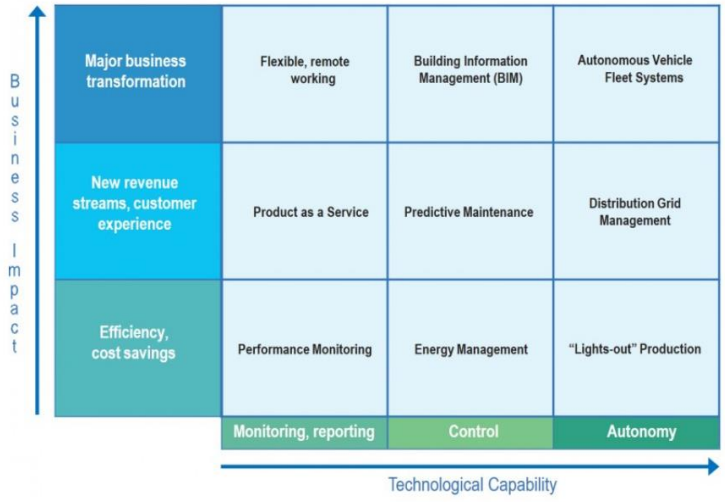


Figure 2. IIoT Solutioning areas - Cambashi / Connected World, July 2020

The most digital transformation projects will be winners because many global enterprises will accelerate digitalization to support flexibility in working arrangements and production location. Visionary global enterprises will see the demand shock as an opportunity to invest in transformative digital technology such as Building Information Management) and Autonomous Vehicle Fleets, to gain the rewards in the recovery from the current COVID19 Pandemic. On the other hand, some of the Industry 4.0 transformation initiatives using IIoT Solutions in industries badly affected by the demand shock and cash-flow issues will suffer.

There will also be winners, where more emphasis is placed on efficiency and cost-saving investments that have a quick payback, such as selling Product as a Service, Predictive and Preventive Maintenance, etc. Use cases likely to be losers include Remote Exploration for Oil and Gas due to the Oil Price, and investment in exotic Transportation Technology, such as Autonomous Drone Taxis. One exception will be visionary global enterprises that see the downturn as an opportunity to invest to gain the rewards in the recovery. Another possibility is that the travel constraints caused by the pandemic might accelerate Digital Transformation initiatives and 5G Adoption, but this has yet to be proven.

3. RESULTS AND DISCUSSIONS

With the previously mentioned objectives of study in view, the approach of the study will be multi-dimensional involving actual requirements and expectations of global enterprises for IIoT services as following:

1. Analysis of published research work in national and international journals. The data included in the projects and research work of leading global enterprises and industries in terms of various IIoT Business Models and their associated parameters considering the current COVID19 pandemic.
2. The survey of questionnaire in leading global enterprises like Manufacturing, Precision Engineering Design, Food Processing, Pharmaceutical, Textile & Garments, Retail, IT, ITES, and Service sector. The data will be gathered in form of questionnaire and will be carried out in the relevant area of research such as reason behind adapting IIoT enabled services and solution offerings.
3. The survey of platforms and data that IT industry is utilizing to implement the effective solution for enterprises. The in-depth discussion with the project managers and team leaders of global enterprises.

The study is limited to leading global enterprises in most of the global economic sectors. The major economic sectors include Manufacturing, Precision Engineering Design, Food Processing, Pharmaceutical, Textile & Garments, Retail, IT, ITES, and Service sector. The sample area for data collection from leading global enterprises will be limited to most of the global economic sectors. Industrial companies will take different approaches to leveraging the power of IIoT in challenging times, but three actions are always helpful when getting started. Moving quickly and leveraging off-the-shelf IIoT solutions, including those from technology providers and machinery OEMs, to maintain critical operations; these solutions can enable a rapid shift to remote operations.

Undertaking improvements, including large-scale connectivity rollouts and cybersecurity investments, especially if operations are slow to build resilience and become more competitive. Reforming the operating model with IIoT solutions; non-operations employees who may have idle time during a crisis can help assess, prioritize, and prepare long-term solutions that will allow companies to thrive and emerge stronger than ever when the pandemic abates. IIoT in manufacturing could generate so much business value and return on investments that it will eventually lead to the Fourth Industrial Revolution, also referred to as Industry 4.0. The potential for growth from implementing IIoT may generate $12 trillion of global GDP by 2030.

The impact of the COVID-19 pandemic on connected applications (IIoT) will be serious, but temporary; there will be winners and losers depending on how the business applications are affected by market drivers. To show the effect by industry, country, and application and indicate where the winners and losers are likely to be, this is still projected to be a high growth sector and further research is planned to predict the shape and growth of the next phase. Given the complexity of the ecosystem, providers will need to understand how to position themselves to capitalize on new growth opportunities. Industrial Internet of Things also has a second meaning to complicate things.Industrial giant GE coined the term Industrial Internet which really describes industrial transformation in the connected context of machines, cyber-physical systems, advanced analytics, AI, people, cloud, IoT edge computing and so forth. Although you won't find the term cyber-physical systems (essentially Industrial IoT in the first sense in action and in a context of autonomous and semi-autonomous decisions and actionable intelligence) because Industrial Internet in many ways is the same as Industry 4.0. This has something to do with Industrial IoT. GE and the Industrial Internet Consortium or IIC (co-)founded decided that the Industrial Internet of Things or IIoT was a synonym for the Industrial Internet.

One can wonder why you need two terms to describe the same thing. When vendors are involved one can then think sales, marketing and compare how often the term Industrial Internet is searched for and how often terms such as Industrial Internet of Things, IIoT and Industrial IoT are searched for. At the end of the day all these terms are inter-related and have a significant correlation to be established by the means of use cases based approach. That does not mean that Industrial IoT in the sense of Industrial Internet does not make sense, well on the contrary of course. The core focus in most of the Industrial Internet of Things (IIoT) solutions and in most global organizations de facto is still on operational efficiency along with cost optimization. Or as IDC called it: efficiency optimization and linking islands of automation as key drivers.

A more holistic approach with additional revenue and innovation goals is needed. Such a holistic strategy already exists in more 'mature' industrial organizations, which have shifted to the business model, service and new revenue opportunity side with tangible results and innovative solutions. They are poised to be disrupters in their respective industries where competition is already intensive and market conditions uncertain and complex. On the other hand, to move up in the IIoT maturity and possibility/opportunity reality, industrial organizations obviously need to start somewhere. Knowing the market challenges and the

lowest hanging fruit in many industrial markets it is normal that in initial stages connectivity in the IIoT space is focusing on a restricted set of goals and benefits.

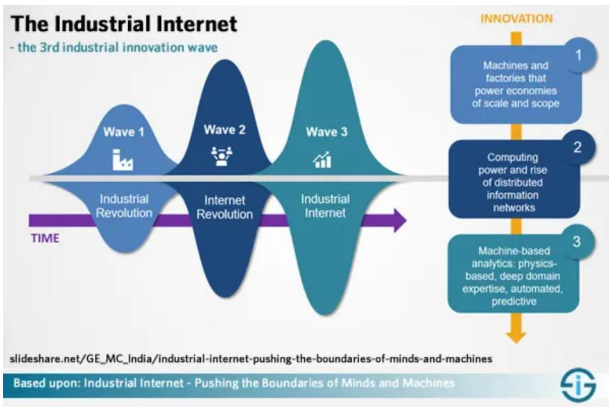


Figure 3. Innovation around The Industrial Internet - i-scoop.eu / Slideshare.net / GE_MC_India

A more holistic approach with additional revenue and innovation goals is needed. Such a holistic strategy already exists in more 'mature' industrial organizations, which have shifted to the business model, service and new revenue opportunity side with tangible results and innovative solutions. They are poised to be disrupters in their respective industries where competition is already intensive and market conditions uncertain and complex. On the other hand, to move up in the IIoT maturity and possibility/opportunity reality, industrial organizations obviously need to start somewhere. Knowing the market challenges and the lowest hanging fruit in many industrial markets it is normal that in initial stages connectivity in the IIoT space is focusing on a restricted set of goals and benefits.

Yet, it is important to have a roadmap or plan for the longer term. It is not a coincidence that the holistic challenge we see in the evolution of IIoT is the same as the one we see in the digital transformation of manufacturing, the main IIoT market. Last, but not least, optimization and automation are not the enemy of customer-centricity in the larger industrial context where speed and enhanced processes are what customers expect. What matters most to us is not the jargon but the results although it would be nice if everyone spoke the same language and did not toss up new terms the whole time. In that regard you can also compare with the Internet of Everything, a term Cisco coined and used up until 2016. In many regards the Internet of Everything in an industrial context is closer to Industrial IoT, the GE way, than to Industrial IoT in the first sense.

The industrial internet of things (IIoT) refers to the extension and use of the internet of things (IoT) in industrial sectors and applications. With a strong focus on machine-to-machine (M2M) communication, big data, and machine learning, the IIoT enables industries and enterprises to have better efficiency and reliability in their operations. The IIoT encompasses industrial applications, including robotics, medical devices, and software-defined production processes. The IIoT goes beyond the normal consumer devices and internetworking of physical devices usually associated with the IoT. What makes it distinct is the intersection of information technology (IT) and operational technology (OT). OT refers to the networking of operational processes and industrial control systems (ICSs), including human machine interfaces (HMIs), supervisory control and data acquisition (SCADA) systems, distributed control systems (DCSs), and programmable logic controllers (PLCs). The convergence of IT and OT provides industries with greater system integration in terms of automation and optimization, as well as better visibility of the supply chain and logistics. The monitoring and control of physical infrastructures in industrial operations, such as in agriculture, healthcare, manufacturing, transportation, and utilities, are made easier using smart sensors and actuators as well as remote access and control.

In the context of the fourth industrial revolution, dubbed Industry 4.0, the IIoT is integral to how cyber-physical systems and production processes are set to transform with the help of big data and analytics. Real-time data from sensors and other information sources helps industrial devices and infrastructures in their "decision-making," in coming up with insights and specific actions. Machines are further enabled to take on and automate tasks that previous industrial revolutions could not handle. In a broader context, the IIoT is crucial to use cases related to connected ecosystems or environments, such as how factories become smart factories. The consistent capturing and transmitting of data among smart devices and machines provide industries and enterprises with many growth opportunities.

The data allows industries and enterprises to pick up on errors or inefficiencies in the supply chain, for example, and immediately address them, thus pushing for day-to-day efficiency in operations and finance. A proper integration of the IIoT can also optimize the use of assets, predict points of failure, and even trigger maintenance processes autonomously. By adopting connected and smart devices, businesses are enabled to gather and analyze greater amounts of data at greater speeds. Not only will this enhance scalability and performance, but it can also bridge the gap between the production floors and general offices. Integration of the IIoT can give industrial entities a more accurate view of how their operations is moving along and help them make informed business decisions. Despite numerous articles circulating the internet claiming that the IoT Platform market is showing signs of consolidation, our research shows that the exact opposite is happening: The market is becoming even more fragmented. Of the 450 IoT Platform companies that made the IoT Analytics list in 2017, 47 ceased operations and 70 were acquired. Of the 70 acquired, 22 continue to operate standalone.

3.1. Current Positioning of IIoT in a Global Context

One may think that this reduces the total number of IoT Platforms to 355. However, through our research of hundreds of websites, presentations, and other materials, IoT Analytics identified an additional 265 IoT platforms which satisfy the IoT Analytics definition of IoT Platform, thereby bringing the total number up to 620. These additional companies include new IoT Platform startups like IOTech (founded in 2017) as well as IoT platforms provided by larger companies or joint ventures (e.g., Adamos - founded 2017, Open Manufacturing Platform by BMW and Microsoft - launched 2019). There are several reasons why many of the small players continue to survive in a market with hundreds of competitors. There are many niches in IoT.

By focusing on specific use cases or industries, some firms bring a value proposition to customers that the larger more horizontal players cannot. It is easy to become an IoT platform company on paper. Several companies seem to have gone the route of doing a customized IoT software project with a customer and afterwards standardizing the elements of that solution to market them as a platform. Many smaller providers are profitable. Their customers seem to enjoy the service they are getting so one can imagine these players to continue to exist for a while. As per the IoT Analytics Report, while the IoT Platform market is not consolidating, it is concentrating around a few key providers. The top 10 of the 450 providers in 2017 held about 44% of the market share according to IoT Analytics estimates. In 2019, the top 10 of the 620 providers are estimated to hold 58% market share. The Public Cloud Computing Service Providers AWS and Microsoft stand out. Both firms have added tremendous capabilities to their IoT platform offerings since 2017. At that time, their IoT Platform offerings were limited. In April 2018, Microsoft committed an investment of $5B to their IoT offering. The investments seem to have started to pay off.

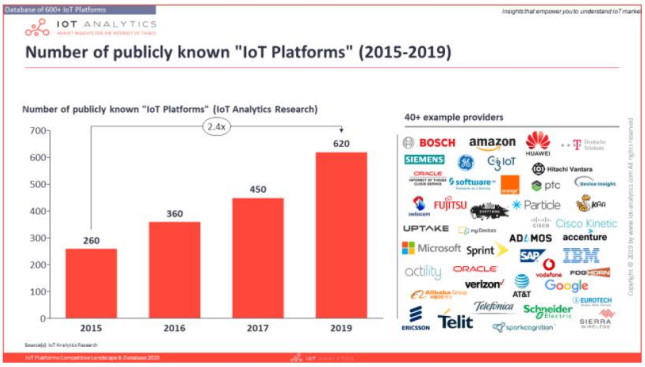


Figure 4. Number of publicly known “IoT Platforms” (2015-2019) - IoT Analytics

Both companies rank very well in the list of top 10 IoT Platforms by revenue and they also dominate end-user satisfaction of IoT platforms. One should note that there are some large well-known multi-national companies that do not manage to keep up with the pace of the market and therefore seem to be falling behind. Instead of pulling out of the market, some of these firms are quietly retracting their IoT Platform marketing and using the existing platform technology to build their own IoT software applications (SaaS) instead e.g., focusing on specific end-user applications such as machine health monitoring or factory OEE analysis. The article that described the research findings of the 2017 IoT Platform companies landscape highlighted the fact that leading platforms were growing 50%+ at that time. While the growth rates are slowly coming down, most providers are sustaining very high growth rates (e.g., Software AG ~50% Q3 2019 vs Q3 2018). On

average, the market is still growing at around 40% and has become a single-digit billion-dollar market that is expected to grow into double digit $B territory within the next 2 years. 50% of all globally profiled IoT Platform companies now have a dedicated focus on manufacturing/industrial use. Many of those companies highlight numerous case studies on their own website that showcase how their technology has helped manufacturers save costs or capture new revenue streams. Typical use cases of IoT Platforms in the manufacturing space include condition monitoring and predictive maintenance. The other two large target areas for IoT Platforms are Energy (34%) and Mobility (32%).

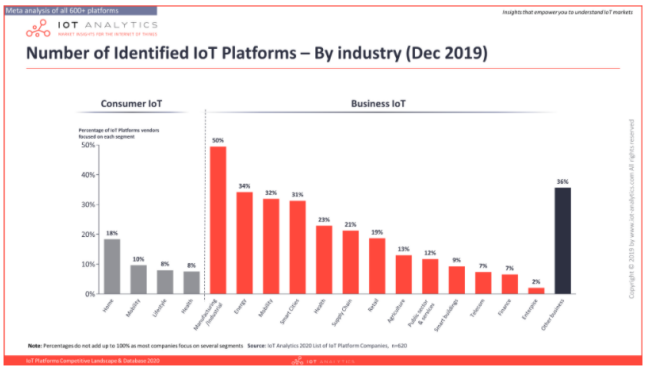


Figure 5. Number of Industry Identified "IoT Platforms" (Dec 2019) - IoT Analytics

The 4 major IoT Platform related findings are explored in much further depth in the 70-page "IoT Platform Competitive Landscape & Database 2020 report". The report also provides a detailed excel database with 40+ columns of information for 620 IoT Platform companies currently on the market today. A meta-analysis of the database provides market breakdowns by region, country, city, tech stack, industry and by number of case studies. Furthermore, recent news and current market trends are outlined in the report. One should note that there are some large well-known multi-national companies that do not manage to keep up with the pace of the market and therefore seem to be falling behind. Instead of pulling out of the market, some of these firms are quietly retracting their IoT Platform marketing and using the existing platform technology to build their own IoT applications. In 2016, manufacturing operations alone accounted for an IoT spend of $102.5 billion on a total of $178 billion, all IoT use cases in manufacturing combined. With a total spend of $178, manufacturing overall is by far the largest industry on the IoT, IIoT and the segment of manufacturing operations outweighs other IoT use case investments across all industries included. Two other IoT use cases which are important in manufacturing from a spending perspective, on top of operations, are production asset management and maintenance and field service, according to the mentioned research by IDC, released early 2017. Transportation represents the second largest market from an Internet of Things spending perspective. Transportation and logistics (T&L) firms are looking to move up the value chain with advanced communication and monitoring systems, enabled by IoT. The global connected logistics market is poised to grow at a CAGR of approximately 30% until 2020. The transportation market reached an IoT spend of $78 billion and is poised to continue to grow rapidly, just as is the case for the IoT manufacturing market. The main use case in transportation is freight monitoring, good for a large majority of overall transportation IoT spend with a total of $55.9 billion and remaining a key driver in the market until 2020.

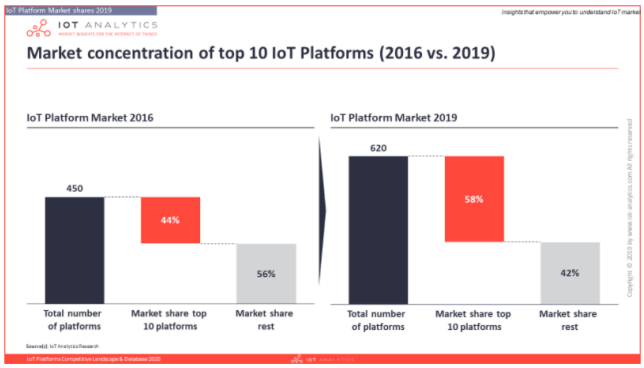


Figure 6. Global Market Concentration of top 10 "IoT Platforms" (2016 vs. 2019) - IoT Analytics

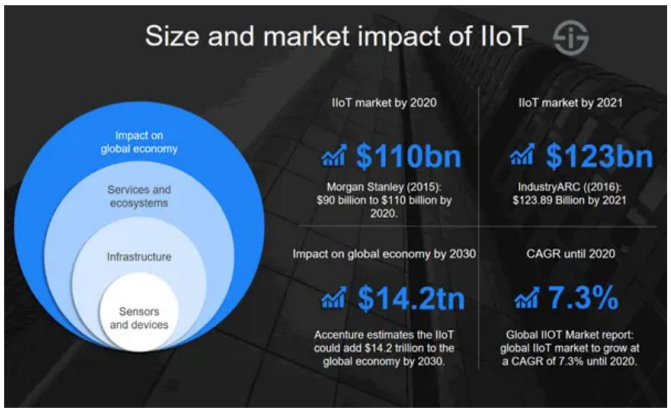
Back in 2016, manufacturing operations accounted for an IoT spend of $102.5 billion on a total of $178 billion, all IoT use cases in manufacturing combined. With a total spend of $178, manufacturing overall is by far the largest industry on the Internet of Things and of the Industrial IoT and the segment of manufacturing operations outweighs all other IoT use case investments across all industries, consumer included. Two other IoT use cases which are important in manufacturing from a spending perspective, on top of operations, are production asset management and maintenance and field service, according to the mentioned research by IDC, released early 2017. Transportation represents the second largest market from an Internet of Things spending perspective. Transportation and logistics (T&L) firms are looking to move up the value chain with advanced communication and monitoring systems, enabled by IoT. The global connected logistics market is poised to grow at a CAGR of approximately 30% until 2020. The transportation market reached an IoT spend of $78 billion and is poised to continue to grow rapidly, just as is the case for the IoT manufacturing market.

The main use case in transportation is freight monitoring, good for a large majority of overall transportation IoT spend with a total of $55.9 billion and remaining a key driver in the market until 2020. If we look at the overall IIoT evolutions in transportation and logistics, we see the growing emergence of a digital supply chain and connected logistics reality, which is at the same time one of the challenges for the manufacturing industry. Despite the link with factories, manufacturing and heavy industries like mining, aviation, oil and gas, defense, power and electricity and energy overall, as mentioned the IIoT is often also used to describe several Internet of Things applications outside of the Consumer Internet of Things. So, de facto it is also used for industries such as agriculture, connected logistics, finance, the government sector (including smart cities), healthcare (hospitals) and cross-industry IoT use cases such as smart buildings in a context of facility management. Depending on the view and industries that are understood in an Industrial Internet of Things context, this leads to less or more IIoT use cases.

Below are a few typical IIoT use cases and business contexts, if we broaden IIoT beyond only manufacturing and the likes:

1. Smart factory applications and smart warehousing.
2. Predictive and remote maintenance.
3. Freight, goods, and transportation monitoring.
4. Connected logistics, Asset tracking and smart logistics.
5. Smart metering, Smart environment solutions, Smart city applications, and Smart farming
6. Livestock and inventory monitoring.
7. Industrial security systems and Asset performance management.
8. Energy consumption optimization, Industrial heating, ventilation, and air conditioning.
9. Manufacturing equipment monitoring, gas, and temperature monitoring in industrial environments
10. Safety and health (conditions) monitoring of workers.
11. Remote service, field service, remote maintenance, and control use cases.

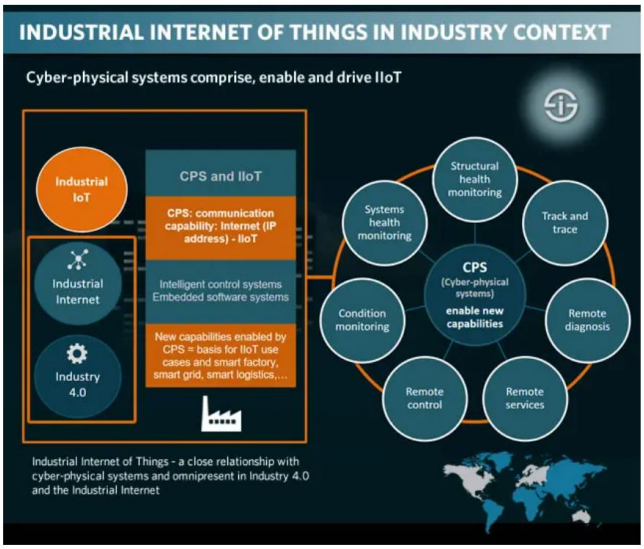
The market opportunity of the IIoT is huge. According to Industry ARC research, the overall IIoT market is estimated to reach $123.89 Billion by 2021 at a high CAGR, as we cover in our Industrial Internet of Things market state and outlook 2016-2017. In the graphic below you can also see some forecasts by Morgan Stanley, data on the impact of IIoT on the global economy by Accenture and another forecast from Research and Markets. Leaders in the IIoT space, such as GE, also have impressive forecasts.



Size and market impact of the Industrial Internet of Things – source: Morgan Stanley, IndustryARC, Accenture and Research and Markets.

Figure 7. IIoT Market Impact - Morgan Stanley, IndustryARC, Accenture and Research & Markets

According to data from Dell, the benefits reported by manufacturing executives who deployed Industrial Internet of Things applications are clear: 53 percent of manufacturing executives utilizing Industrial Internet of Things reported an improvement in business innovation. Overall, 50 percent of manufacturing leaders increased their competitive edge. 50 percent also says to have reduced Total Cost of Ownership (TCO). It isn't too late to attach intelligent IoT gateways to existing industrial assets in the combination of IT and OT, what the IIoT is about, and let them become key providers of insights using IIoT data and analytics, Dell says. These insights can be used to innovate and optimize what you do with those assets, even if they were not designed to gather data. In the end, the manufacturing segment is the largest segment in the Industrial Internet of Things market and Industry 4.0 is seen as the main enabler of this big increase. As already mentioned, partnerships between OT and IT are crucial. But of course, also the business decision makers need to be involved. Go even further and forge partnerships and join forces with parties that might seem less obvious as is recommended by IDC for any digital transformation project. The European region was the market leader in industrial internet of things market in 2015 with approximately 28% of the Total Market and is estimated to grow at a CAGR of 22.2%. Industrial IoT market will see a high demand from the growing IIoT penetration in manufacturing, transport, and energy sectors. The manufacturing sector enabled by industry 4.0 will lead the industrial IoT market in the forecast period while healthcare segment will witness the highest CAGR of 59.8%. This is followed by the Energy sector which is complimented by Smart Grid penetration and will observe the second highest CAGR of 39.7% in the forecast period.



Industrial Internet of Things – relationship with cyber-physical systems and omnipresent in Industry 4.0 and the Industrial Internet

Figure 8. Size and Global Market impact of IioT - i-scoop.eu

The Industrial Internet of Things takes a central place in the industrial transformation projects which are initiated, developed, and implemented in nations and industry bodies across the globe. We already mentioned some previously and as promised to take a deeper dive. Why you need to know the global initiatives regarding IIoT: architectures and standards. It is important to know the industry bodies, understand what industries they cover and how the IIoT fits in. It's important to see how these different initiatives, the reference architectures they develop and the publications they put out, IIoT standards and so forth evolve and how they collaborate and try to align with each other. This is important because of the standardization and the promotion of the usage of the Industrial Internet of Things is key in their efforts, standards are essential in IIoT and at one point or the other there will be certification to see if Industrial IoT products and solutions are compatible with the requirements which are agreed within the bodies that laid out the rules. Global companies require global IIoT know-how and operational flexibility.

Next, there is the fact that most of the global industries such as manufacturing, logistics, oil, and gas and so forth are typically international. Companies such as GE, Siemens and Bosch operate across the globe and are often members of several industry bodies at the same time. Manufacturers and logistics firms (also think shipping, aviation etc.), even smaller ones, operate in a global context as well, and finally all the providers of Industrial Internet of Things solutions, on top of the three mentioned ones (think Cisco, IBM, SAP etc.) also work globally (and are active members of these consortia). Finally, the several initiatives and

industry bodies are key sources for in-depth material regarding the Industrial Internet of Things. They come with a wealth of information, best practices, and recommendations about, among others, IIoT. In other words: they also help you succeed if you have an Industrial Internet of Things project or broader project in which IIoT fits. The several national, regional, and global industry bodies and initiatives, which de facto put the Industrial Internet of Things at the center of their efforts, have different names, frameworks/models, and approaches, depending on their background. An overview of the main ones. The Industrial Internet of Things in the Industry 4.0 Platform view Originating in the German manufacturing industry and government, Industry 4.0 is gaining more attention across Europe and the globe.

Its focus is manufacturing and logistics with an important role for cyber-physical systems. IIoT and cyber-physical systems in Industry 4.0 Although strictly speaking cyber-physical systems are not the same as the Industrial Internet of Things, IIoT is essential in the overall Industry 4.0 vision. Its building blocks, cyber-physical systems, are based on the newest control systems, embedded software systems and the ability of connection using an IP (Internet Protocol) address. This means that cyber-physical systems share numerous characteristics with the Internet of Things and certainly the Industrial Internet of Things: the bridging of a physical and cyber reality and the ability to connect to 'the Internet'. Cyber-physical systems, in the view of Industry 4.0 are a next stage in engineering and mechanics and essentially that next stage IS the Industrial Internet of Things (the connectedness of manufacturing assets, products and production processes, with a strong focus on data). Cyber-physical systems in the Industry 4.0 view are the building blocks of Industry 4.0, but they also enable new capabilities for manufacturing and more. The new capabilities in Industry 4.0 are IIoT use cases, enabling smart industry. These capabilities are essentially what we also call IoT or IIoT use cases, within the industrial focus of Industry 4.0: track and trace, structural health monitoring, remote diagnosis, and control: they are all typical use cases.

3.2. IIOT Solutioning and Service Offerings in the current Global Economy Scenario of COVID19 Pandemic

The new capabilities (or IoT use cases), again in the view of Industry 4.0 in turn enable anything 'smart': the smart plant, smart factory, smart logistics, smart home, smart building, you name it. The link is clear. As it can be read on the internet, the Boston Consulting Group sees Industry 4.0 as the convergence of nine digital industrial technologies: advanced robotics, additive manufacturing, augmented reality, simulation, horizontal/vertical integration, cloud, cybersecurity, Big Data and Analytics, and the Industrial Internet. The Industrial Internet of Things comes back in virtually all the mentioned converging technologies. Advanced robots and cobots need IoT, simulation (think digital twins) needs IoT, Big Data de facto is (also) about IIoT data, the list goes on. What else you need to know about Industry 4.0 and IIoT Funny enough, the Industrial Internet, which we'll tackle next and is mentioned as a technology by BCG (which it really isn't though) is all about IIoT and another industry group: The Industrial Internet Consortium. Its main task is to promote and standardize the Industrial Internet of Things. While Industry 4.0 as said originates from Germany and has a background in engineering, manufacturing, German government efforts in industrial transformation and academia, it is spreading. This is, among others due to efforts of German 'Platform Industry 4.0' to put Industry 4.0 as a European standardization platform. This is done within EU institutions, by bilateral agreements with countries such a France and Italy, which just as other European countries have their own industrial transformation projects with the IIoT taking center stage such as smart factory (e.g., The Netherlands), Industry of the Future (France) and more.

1. As with remote-collaboration tools, vision-based control systems can play an increasingly important role during the current crisis. For instance, systems that analyze video feeds can be combined with infrared imaging to detect fevers. Together, these tools can assist with the identification of infected or infectious employees, monitor physical distancing, and ensure that sick employees remain home. Some companies combine low-tech measures with vision-based control systems for the same purposes. Amazon, for example, takes body temperatures of workers at the entrances to warehouses. It also uses machine-learning software to analyze footage from on-site video cameras to ensure that employees are maintaining safe, recommended distances from one another during shifts. IIoT can allow companies to maintain operations when public-health interventions forbid or limit on-site work by monitoring and controlling equipment remotely.
2. To implement such services, companies must connect critical assets to cloud-based control software. Machinery OEMs and vendors of industrial control software offer connectivity kits and software extensions for most equipment. Employees can then establish access to these tools from home while adhering to the highest security standards to protect their companies and customers. IIoT-enabled inventory management can help industrial companies reduce inventory and thus directly free up liquidity. For instance, sensors can monitor container-fill levels at a single site using ultrasound. Other applications can track the flow of materials over long distances by using geo tags in

combination with integrated mobile communication. This real-time transparency allows the logistics team to manage the material flow more accurately and order raw materials and other inputs closer to the date they are needed, reducing inventory. Although results vary by industry and company, IIoT can help reduce overall inventory levels by up to 36 percent.

3. Like inventory management, IIoT can provide transparency about the waste created during the production and its root cause. These insights help save cash because less raw material is needed to produce the same quantity. For mass production, companies can achieve significant savings by installing basic measurement devices, such as scales and in-line sensors that send information via IIoT. For example, a packaging company started to measure the length and weight of the plastic film thrown away and began to incentivize machine operators to reduce waste. These efforts helped reduce waste by 20 percent in under six months. Instead of replacing a machine part after a certain time, companies can extend its lifetime by measuring its condition with IIoT sensors. If a repair is not warranted, companies can delay it beyond the standard period. Improved condition monitoring typically reduces maintenance costs by 10 to 15 percent.
4. IIoT-based software solutions can provide a real-time dashboard of key performance indicators to support shop-floor performance dialogs, increasing transparency. These tools allow the tracking of improvement actions and send alerts to operators via mobile devices. The software evaluates machine data, such as information on overall equipment effectiveness, part production, and quality through IIoT connectivity. Improved performance can help companies boost labor productivity by 20% to 40%. In addition to improving employee safety, experience suggests that remote assistance and maintenance tools can yield a 10 to 40 percent reduction in field-service costs, especially travel, by reducing the need for in-person visits. The gains may be particularly high at machinery OEMs with a large installed base. Many companies have a pressing need to provide employees with remote access and control of various machines. Since many machines are now experiencing higher-than-usual downtime, companies may be able to install connectivity kits on them more easily.
5. To accelerate the rollout, workers could install a connectivity box each time they perform routine maintenance services. Every machine that is connected to the internet will help industrials, since it becomes available for remote monitoring, data collection, and other services. As companies increasingly digitize their manufacturing operations, cybersecurity becomes more important. As with large-scale connectivity, companies can more easily improve cyber security at all levels when asset downtime is high or operations are shut down, since applying fixes will not create major disruptions.
6. Companies can undertake some simple cybersecurity measures, such as critical software updates and firmware updates of hardware, quickly. These small steps help to minimize overall cybersecurity risks. IIoT-enabled asset optimization involves using advanced analytics to identify the root causes and countermeasures related to the three drivers of overall equipment effectiveness (OEE): availability, performance, and quality. For instance, an aerospace supplier had a low OEE when producing an important airplane component. It then used IIoT solutions to monitor and detect certain problems, such as tool wear and missing materials. Based on this sensor information, the company was able to optimize job sequences in a central control room. With these improvements, the company achieved 80 percent OEE. IIoT tools may also help companies discover previously unknown problems within the supply chain. While impact may vary drastically across settings, companies may improve OEE by as much as five percentage points, for example in low-volume, high complexity discrete manufacturing settings. IIoT tools can help companies optimize procurement by using real-time information on inventory levels and production capacity to determine what quantities must be ordered and assist with rapid contract renegotiations. This feature is especially relevant during the current crisis because commodity prices have decreased significantly. Take oil and copper, both of which have decreased in price by about 20 to 25 percent. Optimizing vendor allocations and improving negotiation strategies typically deliver a 2 to 5 percent reduction in raw-material costs. Given current events, these savings will likely be higher now. Next best action for sales and service. This customer-centric use case can increase both revenue and customer satisfaction.
7. Applying advanced analytics to installed base management, companies determine the best actions for sales and service representatives to take next with a particular customer after assessing data about its current machines. Depending on local regulations, such data could include information on real-time and historic machine conditions, as well as customer records. The relevant IIoT tools can also estimate how customers might respond when they encounter certain service issues or are offered various options, such as service upgrades or the supply of spare parts or consumables. The revenue impact of this use case varies significantly by industry, depending largely on the importance of after-sales services. Companies can also apply this use case internally to define the next best action for their own maintenance team, provided that the necessary data are available.

8. IIoT-enabled pricing tools can analyze data on supply and demand from connected assets in near-real or real time, including information on stock levels, available capacity, production schedules, and anticipated delivery dates. Based on this analysis, the tools recommend the best price for a particular date, allowing companies to make updates more frequently. This use case typically increases revenues by up to 5 to 8 percent. It also allows companies to simplify pricing frameworks for new products. IIoT facilitates real-time data exchange between all supply-chain participants, creating an integrated view of production programs, scheduling, inventories, quality, and anticipated delivery times. In addition to building transparency and trust, such tools can also reduce supply-chain costs and risks—for instance, by receiving signals from connected machines when they are running out of raw materials, or by tracking the flow of materials along the supply chain using geolocation tags.
9. With these insights, companies can optimize inventory levels, production planning, and transport utilization through a more holistic approach. Companies will also learn about supply-chain problems more rapidly, allowing them to act before they escalate. IIoT can increase production efficiency of single machines or entire production lines by using advanced analytics to optimize process parameters. The algorithm analyses information. Data from individual machines get combined with information about the overall production program, allowing companies to optimize machine settings based on previous and subsequent production steps. It is difficult to accurately predict the social and economic impact of COVID19 pandemic on IIoT market at global level, but by combining economic scenarios with datasets and prior experience, we can assess its impact on the engineering, manufacturing, and industrial software markets in general, and Industrial Internet of Things in particular. In the short-term to medium-term, the predicted impact on different industries is not uniform. In general, those industries that depend on disposable income, such as those that are travel-related or fashion-related, will be affected more than those that are crucial, such as utilities and medically related industries.
10. The following graph shows Cambashi's (a global market research, industry analysis, consulting & training firm, focused on engineering and industrial software markets) analysis of the connected applications in IIoT market shows that the growth during the last few years has been very positive, and the effect of COVID19 is likely to be for some time ahead. The overall growth is remaining stable for all market areas through the pandemic till the end of 2022 and then picking up again in 2023. Market areas are affected positively or negatively because the connected applications are affected in different ways by the market drivers above. This allows us to identify in some detail, the potential winners, and losers in the IIoT market.

The 2020 analysis of the top Industrial IoT application areas shows that of the 1414 public enterprise IoT projects identified, Manufacturing / Industrial settings are most common (22%), followed by Transportation / Mobility (15%) and Energy IoT projects (14%).

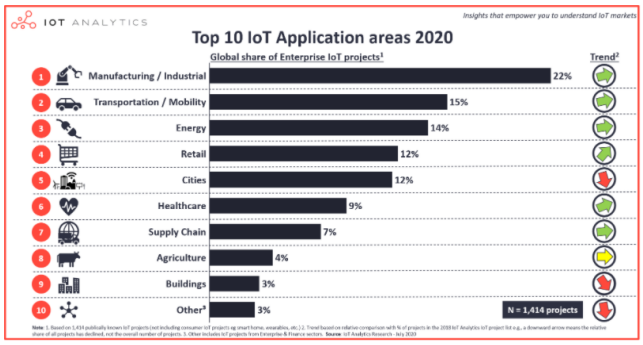


Figure 9. Top 10 IoT Application areas in 2020 - IoT Analytics

Manufacturing / Industrial application area for IIoT has taken over the top spot from "Cities" the number one IoT application area in the 2018 analysis. Technology giants such as Microsoft and AWS as well as large industrial automation players such as Siemens or Rockwell Automation are among the driving forces of the digital transformation in the manufacturing / industrial industry. Industrial IoT is transforming the rules of manufacturing, fueling cloud and edge innovation, accelerating the evolution of digital factories, and enhancing operational performance. Manufacturers and industrial operators are discovering practical ways to apply IoT across their operations, and they are deriving measurable business value as a result. Combining IoT technology and expertise in specific industrial applications enables better collaboration, faster problem-solving and increased productivity. Transportation / Mobility application area for IIoT is the second largest

IoT application area in 2020. Tesla set the industry benchmark for connected cars when it launched the Model S in 2012, introducing the first over-the-air software update capabilities. Since then, pretty much every car manufacturer has followed suit integrating similar IoT technologies. Connected solutions bring increased vehicle and construction equipment uptime for our customers, better safety for drivers, operators, and other road users and of course less emissions of carbon dioxide. The first million connected assets at Volvo are only the start, we are committed to remain a leader in this field. At Honda Innovations, we are witnessing a convergence of technologies that will transform mobility, create new business opportunities, and change the way we manufacture products.

Energy application area for IIoT corresponding to worldwide energy consumption is expected to grow by 40% over the next 25 years, the need for smarter energy solutions has reached an all-time high. IoT is revolutionizing nearly every part of the energy industry from generation to transmission to distribution and changing how energy companies and customers interact. Both solution providers and energy companies themselves understand the need for and value of connected IoT solutions in the sector. Retail application area for IIoT More and more retailers recognize that they can improve their cost-efficiency and in-store customer-experience through innovative IoT use cases. There is a rising interest for retailers to digitize stores and create smarter processes retail now accounts for 9% of the identified projects, up from 5% in the 2018 analysis. The potential to gather data and put it to use more effectively is exciting. We are learning how IoT can help us to work differently. We are improving many of our processes, and we're empowering our associates with better tools and technology. Cities application area for IIoT Smart cities are growing and blossoming in all parts of the world. The IMD Smart City Index 2019, which focuses on how citizens perceive the scope and impact of efforts to make their cities smart balancing "economic and technological aspects" with "humane dimensions", put Singapore, Zurich, and Oslo as the top 3 smartest cities in 2019, followed by many other global smart cities completing the top 10. More and more cities continue to embrace the smart city concept from a citizen's perspective: My brief is to rethink the smart city from the ground up to rethink IoT technology and to focus on what it can do to serve the people.

Healthcare application area for IIoT has only slowly proliferated itself in healthcare. However, things look to be changing considering the center of COVID-19 pandemic. Early data suggests that digital health solutions that relate to COVID-19 are surging. Demand for specific IoT health applications such as telehealth consultations, digital diagnostics, remote monitoring, and robot assistance is increasing. The pandemic has thrust the healthcare industry into the limelight and many C-suites are taking note: There is a huge applicability of technology, data, and communication methodologies to tackle the current pandemic and help improve healthcare solutions through telehealth and telemedicine. Demand is emerging across the globe, there is a growing number of patients being remotely treated globally, for example the number of online consults globally has gone up 50 to hundred times in many health systems already.

These solutions are here to stay even after the current crisis. Supply Chain application area for IIoT considering supply chains extend more and more to the end customers, resulting in more intricate flows of goods that are more complex to deliver, logistics providers are increasingly integrating connected digital solutions to tackle the complexity. A recent survey by Kenco, a US logistics provider, found that 56% of supply chain professionals are currently or planning to invest in sensors/IoT; up from 42% in 2017, to look for more operational efficiencies in how their supply chains operate. The overall transformation of a multinational organization such as A.P. Moller - Maersk from a diversified conglomerate to becoming a focused, integrated, and digitized global logistics company continues. Usage of our digital services has increased significantly over the last year, with more and more customers beginning to explore options for remote management of their supply chains. Agriculture application area for IIoT considering timeline, in 2050, it is estimated that a population of almost 10 billion people will need up to 70 percent more food than we do today. One way to address this challenge is through smart agriculture. IoT sensors can help farmers make more informed decisions to achieve higher crop yield, better quality produce, and save costs by reducing the use of fertilizers and pesticides. Some CEOs see IoT as the main source of disruption for the agriculture industry: Agriculture needs something to drive growth in productivity and sustainable intensification of food production. IoT is the basis of the future of agriculture. Other application area for IIoT There are only a few projects that have been identified that are not part of the other 9 categories. Example IoT Platform-enabled projects in the other areas include those in hospitality, enterprise, finance, and sports.

3.3. COVID19 Pandemic Impact on Global Enterprise Needs

Covid-19 is having an unprecedented impact on our society and our economy. There are also strong indications that many technologies will see accelerated adoption in the coming years because people become more digitally minded as they embrace technology while working from home. But it is required to understand how Covid-19 impacts the Internet of Things, its technology, and its applications. In the last weeks, we did our own research and talked to various IoT decision-makers to understand what the Covid-19 IoT impact in

their organizations is and where they see things going from here. Many companies already use cameras to keep their premises secure and deter theft attempts. Some are also depending on them to ensure that workers comply with COVID-19-related measures. The options on the market often include artificial intelligence (AI) and let people view live feeds from internet-enabled devices. Transportation officials in Paris launched a three-month trial of mask-detection software on public transit. The solution does not store data or use it to punish riders. It gives monitoring personnel a percentage of overall people classified as wearing face coverings. The results could provide public health officials with an idea of how many are compliant. Some IoT solutions function as people counters. They track how many individuals enter a space and alert users when the number meets or surpasses a set limit. These advancements could assist with keeping occupancy numbers at manageable levels, enabling enterprises to prove they are doing all required to abide by distancing requirements and maintain safety. Analytics products for business use are crucial for giving companies complete visibility into what happens inside their premises, even when operating with reduced staff numbers. For example, implementing a solution that shows virtual analytics for an essential system lets technicians keep tabs on characteristics like flow rate and vibration while maintaining social distancing requirements.

Studying the data from a specialized industrial platform makes it easier for enterprises to determine when to send on-site crews to tackle immediate emergencies. They can assess how the circumstances progress from a distance first before increasing staffing numbers.

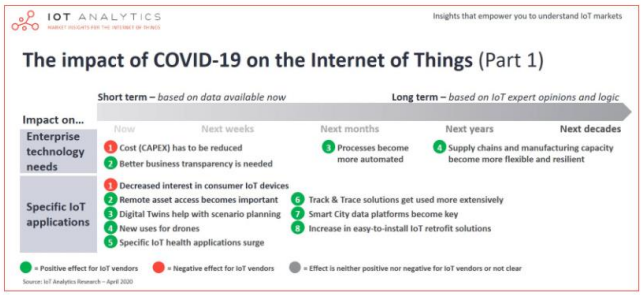


Figure 10. The impact of COVID19 on the Internet of Things for Global Enterprises - IoT Analytics

Industrial analytics could also aid some of the hardest-hit industries in reopening during the coronavirus pandemic. One offering for the food and beverage sector pivoted to focusing on the meatpacking industry after recognizing a need for more smart analytics applications. The data assists companies with screening workers and visitors, staying on top of sanitation needs and abiding by other essential practices to operate safely. Having access to reliable data promotes actionable strategies. Company leaders can depend on intelligent analytics tools to drive their choices instead of making educated guesses about where problem areas exist. A supermarket brand operating in the United Kingdom introduced a "virtual queue" system. People register for places in line and go back to wait in their cars before receiving entrance notifications on their phones. The company made this change after its leaders expected social distancing measures to last through at least 2020. Another situation might emerge if employees say the temperature checks required by their companies necessitate arriving to work at least 30 minutes early. In that case, organizations may purchase new IoT thermal imaging cameras.

These devices can take the temperatures of groups from a distance, potentially speeding up temperature checks in practical ways without compromising safety. Industrial analytics platforms can also give enterprises real-time insights about the products or services their customers demand most. Having that data makes it easier for companies to anticipate and prevent shortages or other order fulfillment delays.
Company representatives are also interested in how connected gadgets could expedite contact tracing by identifying those exposed to an infected person. Some wearable options emit sounds if people stand too close to each other. They also let managers backtrack and learn which colleagues worked with someone confirmed to have COVID-19. Such products permit dependence on accurate data when performing contact tracing rather than asking people to rely solely on memory.

Companies also manufacture items that support contact tracing, along with other efforts to keep people healthy. Some gadgets remind people to wash their hands when entering or leaving key areas, such as the cafeteria or restroom. Businesses may also deploy screening apps that workers use every day before clocking in for shifts. Employees would fill out a survey indicating if they experienced any of the listed symptoms. Those that have them can receive notifications through the app to stay home or wait for further instructions. Enterprises could also get data breakdowns that offer warnings of potential increases in

symptomatic workforce members. The complete picture of all 25 effects of Covid-19 on the Internet of Things can be seen in the below figure.

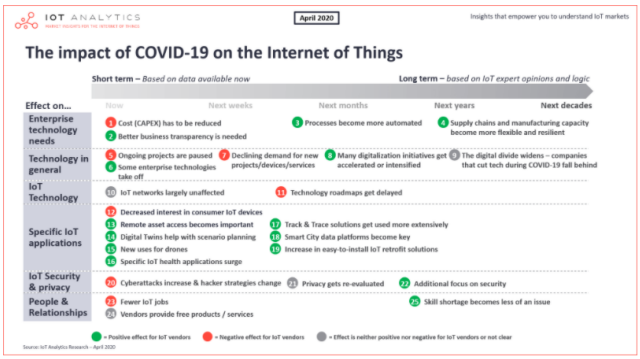


Figure 11. The Complete Picture of COVID19 Pandemic Impact on IIoT Global Market - IoT Analytics

Asia Pacific (APAC) to record the highest growth rate during the forecast period. The increasing demand for IoT in the major APAC countries, such as China, India, and Australia, is predicted to showcase a huge base amidst the COVID-19 outbreak. The COVID-19 outbreak has slowed down most of the economies, such as China, India, Japan, and Australia. However, technological advancements and digitization in countries such as China and India will keep up the demand for IoT in major verticals, such as healthcare and utilities. For Instance, APAC accounted for 42% of the total installed smart meters in 2018, which is expected to increase in the future for remote monitoring and accessibility of the infrastructure during times of such pandemic. Key market players profiled in this report include IBM (US), Royal Phillips (Netherlands), Stanley Healthcare (US), Microsoft (US), Oracle (US), Bosch (Germany), Cloud Minds (US), XAG (China), CBT (US), PTC (US), Rockwell Automation (US), Honeywell (US), GE Digital (US), Intel (US), Siemens (Germany), Ericsson (Sweden), Hitachi Vantara (US), ABB (Switzerland), NEC Corporation (Japan), Telit (UK), Sierra Wireless (Canada), Itron (US), Arad Group (Israel), Cisco (US), Medtronic (Ireland), SAP (Germany), Software AG (Germany) AWS (US), Softweb Solutions (US), Google (US), hIOTron (India), Sony (Japan), Capgemini (France), Adobe (US), NTT Communications (Japan), Happiest Minds (India), Vodafone (UK), TCS (India), DXC (US), Infosys (India), Verizon (US), Service Group (US), Cognizant (US), and Accenture (Ireland). These players have adopted various growth strategies, such as partnerships and new service launches, to expand their presence further in the impact of COVID19 on the Industrial Internet of Things market and broaden their customer base.

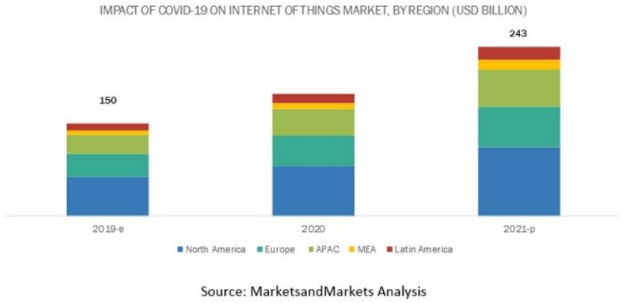


Figure 12. Impact of COVID19 Pandemic on IIoT Global Market by Region - Markets and Markets Analysis

IBM Watson supported the IBM Clinical Development system that an advanced Electronic Data Capture (EDC) system helps accelerate the delivery of safer and more efficacious medicines to the market through IoT. It further helps them reduce the time and cost of clinical trials by providing data and analysis from web-enabled devices. The cognitive operational risk insight tool by IBM collects data from IoT devices, capturing patient data and offering features, such as risk tracking, scenario analysis, event monitoring, and analysis, and decision support. The tool is expected to help healthcare providers to assess underlying conditions in COVID19 patients to help understand the criticality of the disease. The clinical development system is made available for free for various health care providers, to enable them to fasten the process of

clinical trials based on understanding the nature of the COVID19 disease and coming up with a suitable vaccine. The company is also offering a cognitive operational risk insight tool by IBM for free to non-profit organizations during the pandemic, helping them analyze patient data. COVID-19 is considered both a global health crisis and an international economic threat. The restrictions put in place in response to the COVID-19 pandemic has had a devastating effect on many businesses, marketplaces, economics, society, and our lives. The full health, social, and economic consequences of this pandemic and its restrictions will take time to be fully recognized and quantified; however, there are many ongoing efforts in the research and industrial communities to utilize different technologies to detect, treat, and trace the virus to mitigate its impacts. Internet of Things (IoT) technology has shown promising results in early detection, quarantine time, and after recovery from COVID-19; however, as we learn more about the virus and its behavior, we should adjust and improve our approaches in different phases. For example, it would be interesting to integrate Artificial Intelligence (AI) and IoT technology to use AI power to minimize interactions between healthcare workers and patients in all phases. Another example is using touchless technology with the help of other inputs (such as gesture and voice) that could efficiently lower the spread of the disease and end the pandemic sooner. Further research needs to be done on convincing confirmed cases of COVID-19 to remain in quarantine to mitigate the spread of the virus. Moreover, how can IoT devices help isolated patients efficiently in their daily lives. After lockdown, as businesses and marketplaces are opening gradually, how can IoT devices be incorporated in businesses to cover both safety and efficiency. Answers to those questions will attract considerable attention in both research and industrial disciplines and open new research avenues in this area.

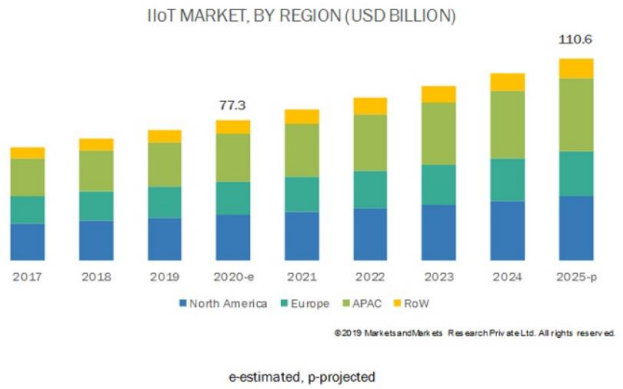


Figure 13. The IIoT Global Market by Regions - Markets and Markets Analysis

One of the main concerns about using IoT devices in different phases of this pandemic is the privacy issue when patients are asked to share their information. This is a big concern for every patient, so defining secure channels for communications or utilizing different encryption techniques before sharing private information would be possible research areas. Having IoT-enabled Smart Cities can be extremely helpful in combating the current and any future pandemic through collaboration between medical centers, cities, etc. Along with IoT applications, Allam et al. emphasize the importance of the concept of Smart City networks while the world is struggling with the COVID19 pandemic. Smart City infrastructure can help people maintain social distancing by the implementation of smart transportation systems including crowd monitoring, smart parking, and traffic re-routing. As a part of smart living in the Smart City, smart home IoT-based technologies can also reduce the infection rate of COVID19. For instance, smart home doorbells and security systems can be implemented to prevent users from touching surfaces, so there will not be any contamination of the virus from touching those surfaces.

While the world is struggling with the COVID19 Pandemic, many technologies have been implemented to fight against this disease. One of these technologies is the Internet of Things (IoT), which has been widely used in the healthcare industry. During the COVID19 pandemic, this technology has shown very encouraging results dealing with this disease. For this paper, we conducted a survey on the recent proposed IoT devices aiming to assist healthcare workers and authorities during the COVID19 Pandemic. We reviewed the IoT-related technologies and their implementations in three phases, including "Early Diagnosis," "Quarantine Time," and "After Recovery." For each phase, we evaluated the role of IoT-enabled/linked technologies including wearables, drones, robots, IoT buttons, and smartphone applications in combating COVID19. IoT technology can be extremely efficient for this pandemic, but it is also critical to consider the privacy of data. By implementing IoT technology properly in a secure way, more patients, with peace of mind, can participate in their treatment using IoT devices. As a result, authorities and healthcare workers can

better respond to pandemics. Consequently, the impact of these types of diseases, including infections, hospitalizations, and death rate, can be significantly reduced.

Since early 2020, the world has been struggling with the pandemic caused by the novel severe respiratory syndrome coronavirus 2 by striving to control the unprecedented spread of the virus and develop a vaccine. As most efforts to find a treatment or control the spread of the COVID-19 have not shown acceptable results so far, there is a high demand for global monitoring of patients with symptomatic and asymptomatic COVID-19 infection. In recent years, IoT technology has received significant attention in the healthcare domain where it plays an important role in different phases of various infectious diseases.

In the current pandemic, as the contingency of COVID-19 is high, there is an essential need for patients to relate to and monitored by their physicians proactively in different phases of COVID-19. In this study, we investigate the role of IoT technology in response to COVID-19 in three main phases including early diagnosis, quarantine time, and after recovery. During the first phase of COVID-19, which is early diagnosis, there is an essential need for faster diagnosis due to the high rate of contagiousness of COVID-19 where even an asymptomatic patient can easily spread the virus to others.

The sooner the patient is diagnosed, the better the spread of the virus can be controlled, and the patient can receive appropriate treatment. In fact, IoT devices can speed up the detection process by capturing information from patients. This can be implemented by capturing body temperatures using different devices, taking samples from suspicious cases, and so on. The second phase, called quarantine time, is an important period of this disease after the patient has been diagnosed with COVID-19, and he or she should be isolated for the course of treatment. IoT devices in this phase can monitor patients remotely with respect to their treatments and stay at home orders by the authorities. They can also clean areas without human interactions. Examples of these types are the implementation of tracking wearable bands, disinfecting devices, etc.

According to the Centers for Disease Control and Prevention (CDC), most people with mild symptoms can recover while staying at home without getting treatments, but there is no guarantee those people will not be reinfected after recovery. Reinfection might happen with different symptoms of COVID-19. Concerning these possible reinfections in the after-recovery phase, the chances of returning symptoms and potential infectivity can be high. To prevent that happening, social distancing should be implemented by deploying IoT devices, including bands and crowd monitoring devices, to track people to ensure the appropriate distance is maintained. In short, IoT technology during the COVID-19 pandemic has proven its usefulness in assisting patients, healthcare providers, and authorities. In this section, we briefly explain the various IoT devices and applications including wearables, drones, robots, IoT buttons, and smartphone applications that are mainly utilized in the forefront of combating COVID-19. The beginning of the year 2020 marks a once-in-a-lifetime health and economic event.

The World Economic Forum says the economic fallout has the capacity to be on par with the Great Depression. Most experts agree that we have a long road ahead of us to ensure that future interactions will not compromise our health and safety. The likelihood of organizations being forced to operate with significantly less staff until a vaccine or a cure is discovered is a reality that companies are preparing for. In this new reality, manufacturers have been forced to adapt to having limited staff on the plant floor while trying to ensure greater access to data and control remotely. The Industrial Internet of Things (IIoT), a connected solution designed to provide increased visibility, holds remarkable power to enable remote condition monitoring, maintenance instructions, production monitoring, and tracking quality.

With data orchestration deployments, IIoT is growing organically right now, from devices and up. IIoT orchestration offers the ability to integrate IIoT with existing business workflows and systems. It also provides a single platform that unifies data from current and future connected devices and systems. Unlocking value from any technology requires more than blind investments. Organizations most likely to pull ahead of their competitors will be the ones that focus on security, performance, and standard implementation to drive success, as well as get their customers on board early. Whether it is the consumer IIoT and the industrial IIoT, IIoT adopters must look beyond the "wow" factor to ensure that they are getting IIoT solutions designed for their needs. Moreover, IIoT devices are becoming a matter of increasing concern in terms of data privacy and cybersecurity aspects. Although emerging devices are easily identified at inception, decades-old technology has become part of the IIoT universe–sometimes stealthily–and must be dealt with. These devices must be properly segmented and managed from a policy perspective because they are a gateway to an organization's broader, connected infrastructure. Emerging IIoT devices are likely to be built and deployed with security in mind. However, more familiar hardware that now has intelligence and connectivity might get overlooked.

IoT, AI, cloud, and big data/analytics are the 'big four technologies' that could provide the bedrock to connect organizations, generate data, and drive more intelligent operations. Using its sensors, network, and analytics, IoT provides the core tools to automate data collection and generate insights. It is the most

important component in the digital stack for the industrial sector. In the following sections, let us understand the market potential that IoT opportunity is expected to create and the drivers that support its adoption.
Since early 2020, the world has been struggling with the pandemic caused by the novel severe respiratory syndrome. Across the world, spending on software and hardware related to IoT is projected to grow rapidly, from US$726 billion in 2019 to US$1.1 trillion in 2023, according to a market research report. A recent IoT industry spending report reveals that Asia/Pacific accounted for most of the spending on IoT in 2019, with India spending US$20.6 billion3. After COVID-19, focus is on conserving cash in India.

The trends such as De-growth in 2020; possibly going into H1 2021, Companies mandated to use IoT to reimagine new ways of operating, and Growth after H2 2021 is expected to be much faster after COVID19 vaccine/treatment is found are expected. The above trend is also corroborated by another recent market research4 covering pre- and post-COVID-19 market analysis. According to this research, the industrial IoT market is expected to grow at a CAGR of 16.7 percent from 2019 to reach US$263.4 billion by 2027.

A few of the compelling reasons why organizations use IIoT are to reduce cost and/or increase revenue, enhance safety and security, and improve product quality. Drivers that are increasing IIoT adoption in the markets include the following: low cost of storing and computing data on the cloud platform; emerging trends on edge computing; falling costs of connectivity, sensors, and devices; and increasing smartphone penetration and mobile app development platforms. In this section, we will focus on key high-value drivers such as cost reduction, revenue growth, security, and safety. These drivers, along with quality control measures, are expected to be critical in accelerating IIoT adoption. Hence, the overall understanding of these elements and the suitable potential use cases that could support the adoption of IIoT is crucial and a real need of today's time.

IoT solutions transforming the healthcare sector Smart watches, fitness bands, monitoring patches, and heart rhythm detectors are examples of IoT-enabled devices that already exist to capture and monitor healthcare data. After COVID-19, the healthcare sector will renew its focus on technology enablement to cope with higher expected load on care facilities. Potential applications of IoT that are likely to emerge in the healthcare sector in India are Real-time access to patient data and improving workflows via sensor-based smart chips, real-time location systems, use of connected thermometers for workplace health monitoring, Use of connected devices for remote patient care, Supply chain traceability for pharma, etc. Smart agriculture can create an exponential impact is the far-reaching impact of climate change on agricultural production is likely to challenge food security in the future. The agricultural sector has realized the need for investing in a technology that enables monitoring soil, weather, and crop conditions. Government of India is advocating the use of sensors in agriculture value chain.

The deployment of IoT sensors to collect and transmit data in agricultural activities will lead to the development of advanced techniques in precision agriculture monitoring. This means avoiding years of wasteful over-consumption of water, fuel, and soil additives, as well as limiting the use of pesticides and fertilizers. IoT devices could also increase the reliability of weather forecasting processes, thus enabling farmers to make more efficient use of their resources and reduce waste. Pharmaceuticals focusing on supply chain visibility Pharmaceuticals is one sector that has seen its outlook improve after COVID 19. Categories such as therapeutic and over-the counter medicines saw supply-side disruptions and demand contraction. Manufacturers are looking for AI-based demand sensing algorithms to simulate multiple scenarios and plan their distribution well in advance.

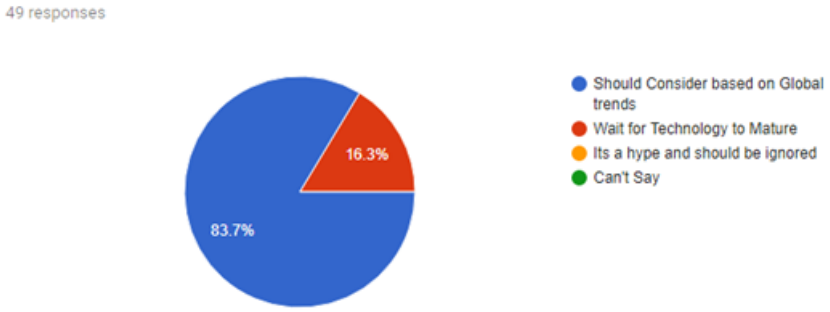
Companies focusing on supply chain visibility and demand sensing as the two main use cases for IoT-enabled projects find Industrial Internet of Things (IIoT) is the best way of getting quality real-time data across the enterprise. This in turns allows for AI models to become more accurate and provide an opportunity for pharma companies to gain visibility to the nth tier in the complex pharma value chain. Specialty chemicals are focusing on supply chain diversification Specialty chemicals is another sector that has benefitted from COVID 19 disruptions. Traditionally, China has been the top supplier of specialty chemicals across the globe.

However, as supply chains diversify out of China, Indian specialty chemicals manufacturers ramped up to increase their volume share. This ensured that demand has gone up significantly in the export market for India-based specialty chemicals companies. Companies in this sector are primarily looking at solutions to connect with the global supply chain through planning integration and demand sensing. This is a growth sector. In the post-COVID-19 world, the focus of specialty chemicals companies has been on tapping greater growth and integration with global supply chains. Other sectors, such as automotive, metals, and mining, are also deriving significant value from IIoT. Therefore, this allows us to predict that IIoT is expected to become a key investment area around later 2021 once cash flows improve.

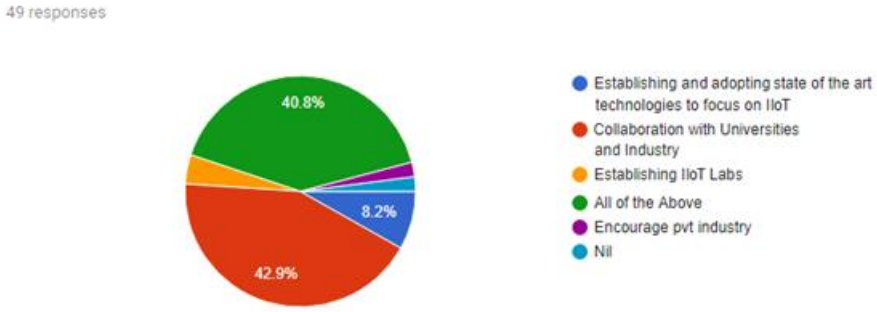
As a part of this research study, we had taken a survey with industry professionals to understand their overall perception about future of IIoT after COVID19 Pandemic. This survey consists of several

questions related to potential applcations, opportunities and challenges for IIoT adoption in the global market and enterprizes context. The summary of responses to this survey are given below:

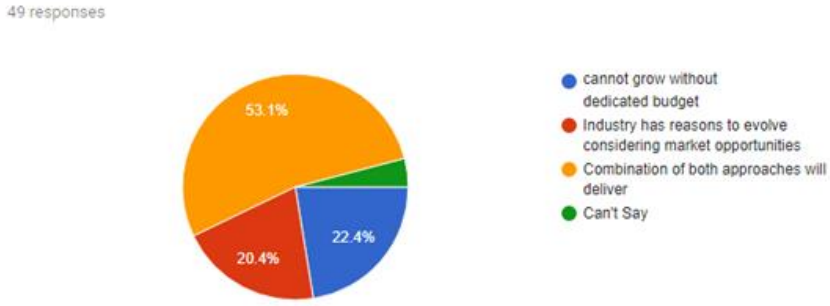
1. Should we consider adopting IIoT Solutionoing in global enterprises or wait for the technology to become more mature after current Pandemic?



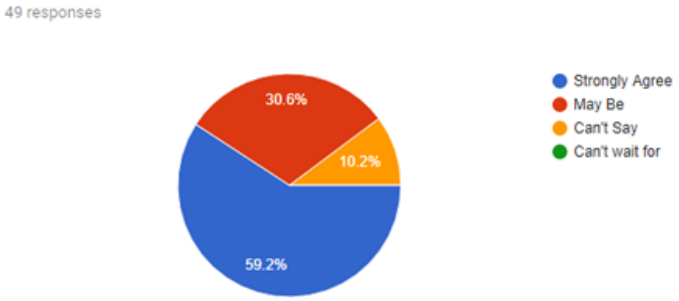
2. How can IIoT Research and Development in global enterprises application areas be gainfully steered considering their overall Industry 5.0 progression?



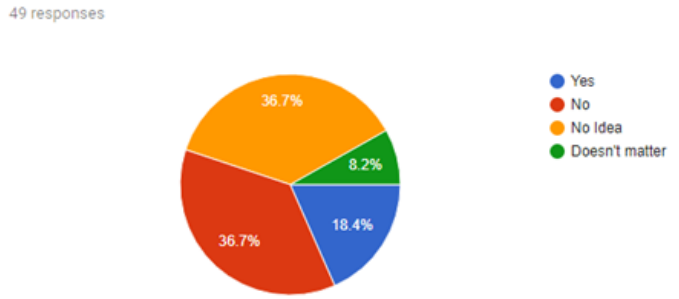
3. Technology Adoption requires Budgetary allocations and funding for research. Do you see any advantage in budgetary allocation approach for substantial R&D and Production or it should be left to the industry to tap market opportunities?



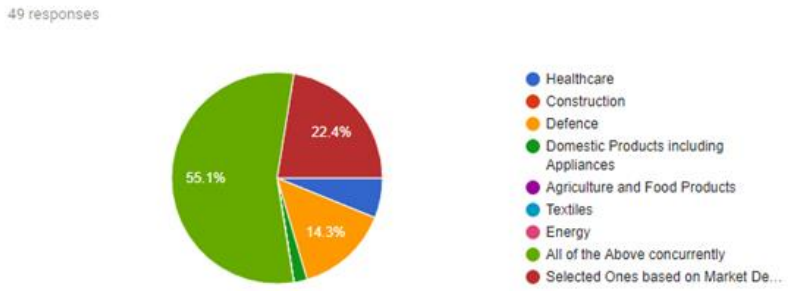
4. The global industrial efforts have produced revolutionary products already, which however are yet to hit open markets due to govt. policies. While billions are already planned to be spent on procuremtn with a shelf life of 30-40 years, are we going to miss on the advantage which is likely to mature in near future.



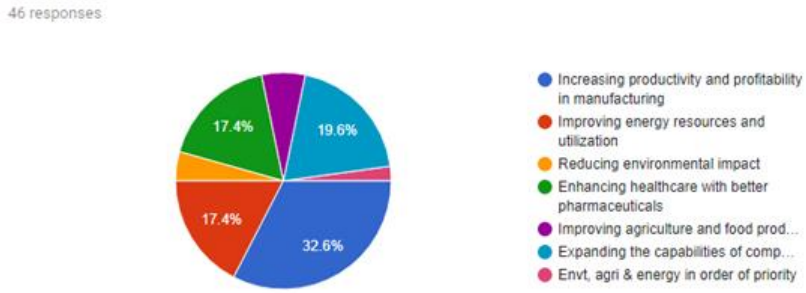
5. IIoT has potential risks and challenges if not regulated properly? Have the standards evolved enough to regulate global IIoT industry?



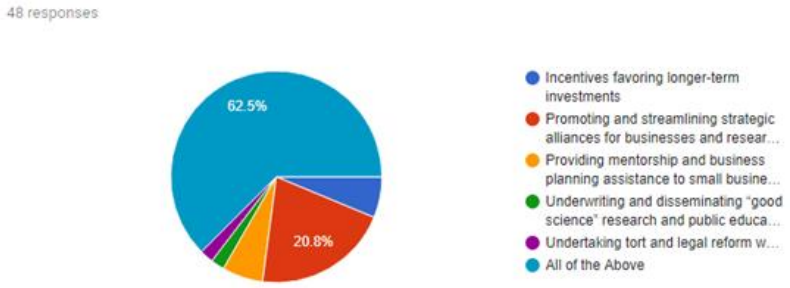
6. IIoT has the potential to cut costs in almost all domains of it applications as compared to current technologies. Recommend areas of applications which are required to be.



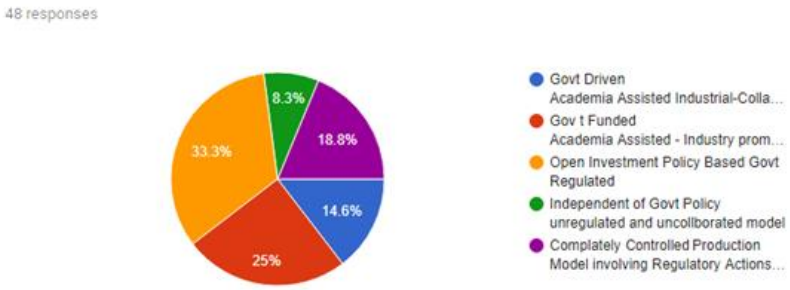
7. Public-Private Collaborations: It is unlikely that the vast field of IIoT would reach the levels of maturity (like other traditional physical science-based industries did) within out lifetimes. This justifies the case for long-term government investment in IIoT technology. Private and institutional investments would grow faster when some of the fundamental technical issues of process scalability and cost of production of new IIoT components as well as associated risks have been more comprehensively addressed. What neared term national concersn need to be targeted by Public-Private Collaborations in applied IIoT to hasten societal support?



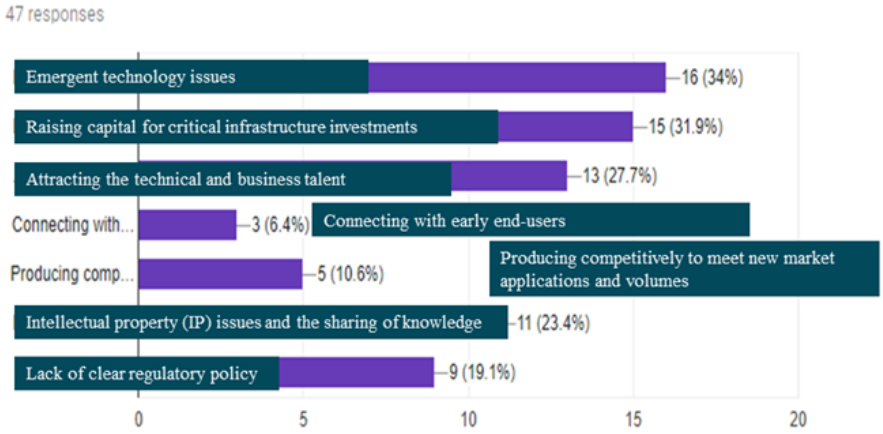
8. Government can lead by defining and funding National priorities and creating meaningful grand challenge incentives for early industrial adopters of IIoT Technology. This will accelarate the broad-based translation of IIoT Technology advances across multiple industry sectors. What areas can be chosen where greater government involvement in IIoT Technolgy can have high National impact while leveraging substantially larger private investments?



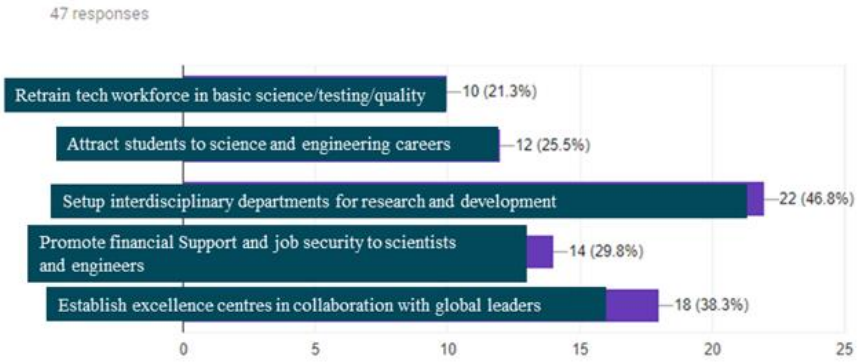
9. What model of Eco-System for IIoT Technology will deliver the most in Global Context?



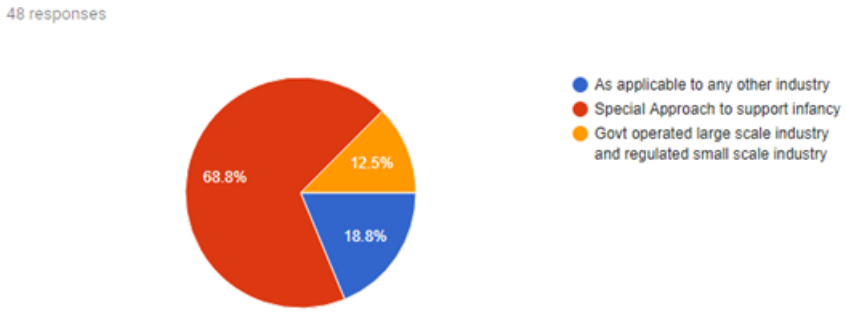
10. What are the critical barriers that need to be first addressed in order to evolve global IIoT market considering future opportunities?



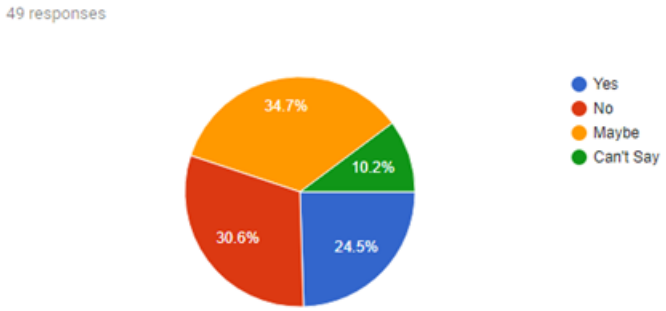
11. Recommended strategy to overcome shortage of qualified manpower/multi-disciplinary aspects?



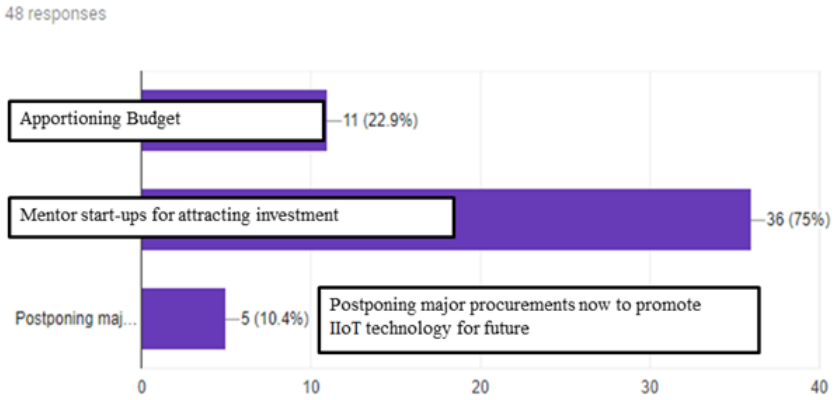
12. While the manufacturing industry faces unique challenges, similarities do exist with other recent technology waves offering many lessons learned for formulation of sound anticipatory approaches. Aggressive R&D investment policies for pursuing targeted investigations in fundamental IIoT Science, Engineering, and Manufacturing Technology needs to be driven, while accelerating adoption for social benefits.What are the industrial approaches that can deliver?



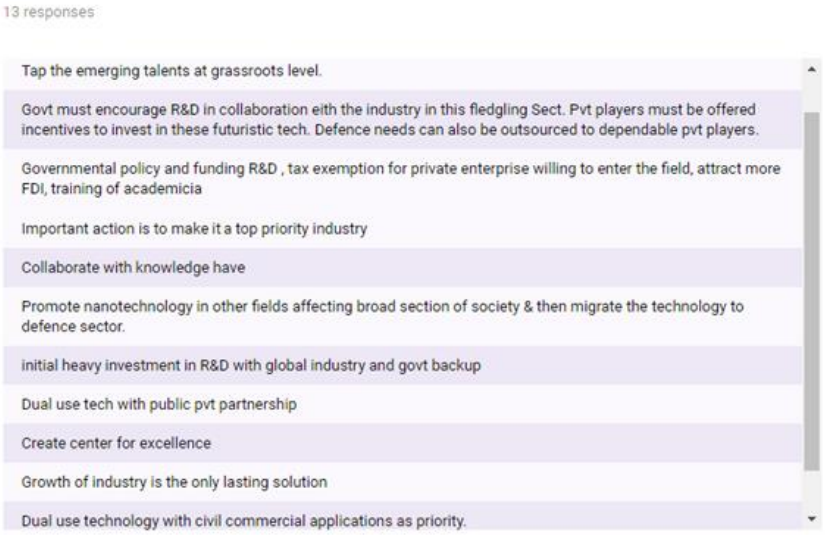
13. Do we have an organizational capability to understand, promote, pursue, adopt, and follow a new technology over existing costlier approaches?



14. Insufficient investment and lack of govt. initiatives can be overcome by?



15. What suggestions would you make for adoption of IIoT Technology in particular and technology in general in order to be cost efficient yet current?



4. CONCLUSION

1. IIoT finds applications in almost every industrial discipline. Almost every IIoT work and achievement accomplished till date can be directly or indirectly related to many types of Technology based applications. The main areas where IIoT can be applied are Technology, IT, Manufacturing / Industrial, Transportation / Mobility, Energy, Retail, Cities, Healthcare, Supply Chain, and many more other areas in both Public and Private sectors. The research is being considerably supported globally to look seriously at various application areas. IIoT Analytics continues to track in which verticals most IoT projects are happening. The fact that more than 1,000 publicly announced IIoT projects now make use of many IIoT platforms highlights the importance and pervasiveness of those IIoT platforms in bringing IIoT solutions, services, and products to market.
2. Considerable IIoT applications are already being materialized world over in the areas of power devices, vehicles, engines, medical devices, drones, robots, and industrial automation. The pattern of IIoT application examples which have emanated in most of the globally developed economies and markets in countries such as USA, China, Russia, and European countries and even in smaller countries have indicated to the diverse interest being exhibited in introducing IIoT products and services in global enterprises. The IIoT has the potential to cut costs considerably while providing solutions which have improved quality, longevity and superiority in terms of providing an operational edge in the evolving challenges in future technological advancements.
3. The IIoT market is expected to grow from USD 77.3 billion in 2020 to USD 110.6 billion by 2025, at a CAGR of 7.4% during the forecast period. The growth of the IIoT industry is driven by factors such as technological advancements in semiconductor and electronic devices, increased use of cloud computing platforms, standardization of IPv6, and support from governments of different countries for R&D activities related to IIoT.
4. As the massive inventory concerns Industry 5.0 initiatives amidst budgetary constraints pulling and pushing priorities or forcing compromises at times, it is prudent to consider IIoT adoption as a strategy, to cut costs, enhance capabilities and meet the ends. An all-encompassing understanding of IIoT at all levels, including representatives of Global Organizations and Enterprises, will unfold new perspectives and open abundant solutions to make defining decisions for the future, today. Largely, the perception is that whole Global Market will follow the global trends in adoption of IIoT in Industry 5.0 context. On the other hand, there also is a school which propagates that it is still early days to consider huge investments in IIoT solutioning. Therefore, the research needs to go further to align the present scenario, future options, and options for gradual adoption.
5. As regards the need for becoming a leading player in Industry 5.0 adoption of IIoT, most opine that robust Govt Policies to drive R&D and Industry, International Collaborations with global leaders, promoting industry through liberal funding and apportioning overall budget for IIoT applications must be considered seriously. Some perceive IIoT as an unproven area and advice against treading the path, probably since the markets are not yet abundant with products that display upfront the use of IIoT solutions, services, and products at the backend.

6. Steering IIoT R&D needs to be undertaken by establishing various Industry 5.0 initiatives for adopting state of the art technologies to focus on brand new IIoT products, services and collaboration with global educational institutes, universities, and industries by establishing excellence centers and labs to steer production by domestic industry is a commonly perceived way forward.
7. IIoT Technology adoption requires budgetary allocations and funding for research. The common feeling is that though industry can see market opportunities, which may not be domestic, yet the Govt funding and promotions will be the key drivers to accelerate Industry 5.0 initiatives and products by domestic industry.
8. The global industrial efforts have produced revolutionary IIoT products already, which however are yet to hit open markets due to govt policies. While billions are already planned to be spent on procurement with a shelf life of 30-40 years, it is felt by most that the advantage may be lost due to the current haste.
9. There is a lot of haze regarding the risk and challenges aspects associated with IIoT and the standards are still evolving. IIoT may remain a policy concern thus unless gets alleviated by the researchers, without coming under the influence of low productivity or other aspects.
10. Another common belief is that the IIoT is a cost cutting technology, in addition to the cost, quantity and other benefits, and must therefore be adopted as a dual technology for societal as well as industrial use.
11. Public-Private Collaborations is necessary for maturity of IIoT solutioning (like other traditional physical science-based industries did) within our lifetimes. This justifies the case for long-term government investment in IIoT specific service offerings. Private and institutional investments would grow faster when some of the fundamental technical issues of process scalability and cost of production of new IIoT components as well as associated risks have been more comprehensively addressed. It is widely believed that the near-term national concerns need to be targeted by Public-Private collaborations in applied IIoT to hasten societal support. Increasing productivity and profitability in manufacturing, improving energy resources and utilization, reducing environmental impact, enhancing healthcare with better pharmaceuticals, improving agriculture and food production, expanding the capabilities of computational and information technologies and prioritization strategies are perceived as the way forward.
12. Governments of worldwide countries can lead by defining and funding national priorities and creating meaningful grand challenge incentives for early industrial adopters of IIoT. This will accelerate the broad-based translation of IIoT advances across multiple industry sectors. Areas that can be chosen where greater government involvement in IIoT can have high national impact while leveraging substantially larger private investments are perceived to be incentivizing long term investments, promoting, and streamlining strategic alliances for businesses and research, providing mentorship and business planning assistance to small businesses, underwriting and disseminating good science research and public education and undertaking tort and legal reforms.
13. There is a common perception regarding the IIoT Business Models which should be adopted, based on different parameters and developments world over. However, there is a larger thinking which needs to be done to evolve models and their deliverance which will define organizations and frameworks.
14. Critical barriers, investment philosophy and inter-related aspects need more scrutiny which will be worth its value only if an approach is inclined to carry forward IIoT and its associated service offerings as a chosen way forward.
15. IIoT is already over the horizon, with immense resolution of the spectrum of applications that it opens, even before it has truly landed. Theoretical and conceptual propositions are on the production table while the skeptics keep hounding in negativism. It has taken decades of research to arrive at the fundamental procedure into industrial automation. Integration of IIoT with advanced computing, biotechnology, material processing and design sciences, which are already immensely mature, have created favorable conditions for IIoT to now take off.
16. For advanced IIoT it took a long time to get through the initial stages. It is hence necessary for the leadership of the Industry 5.0 initiatives and the global organizations to realize its potential and commence awareness programs and encourage initiatives and funding in this field. With the advent of IIoT, the qualitative advances in industrial automation technology will be enormous and compelling; no global enterprise will want to maintain such IIoT based Industry 5.0 initiatives that are effectively impotent against a potential threat. A global enterprise's performance potential will depend first on its position in the technology race.
17. A second factor will be its natural resource base and the involvement of Industry. It is hence essential that the required efforts in ushering in this technology at global level be stimulated and coordinated

by the governments of worldwide countries, the research organizations, and the industries. A large budget may perhaps be warranted for its development.

18. IIoT is the future which is just beginning to unfold. A new age of research, development, and commercialization of IIoT is on the cards considering the immense promise it offers being one of the first broad-based technology areas. US, China, and many European Countries have clearly defined the development and market applications as essential aims from the beginning as both countries aspire to be global leaders in IIoT. As the real products are now coming to the fore and concepts turning into reality, the demand is likely to shift towards IIoT with unprecedented pressure of commercial production and adoption, irrespective of the application areas. Below are the key measures to be taken up by the global enterprises to explore and capture upcoming opportunities to decide the ultimate future of IIoT initiatives in the Global Markets and Economies context.
    a. Proactive Policy Framework to specify responsibilities, actions, and future path by identifying Critical, Non-Critical and Essential Application Areas at national Level.
    b. Identify Application Areas for IIoT Automation based Products and Services and Establish Sustainable IIoT R&D Centers of Excellence for steering research work.
    c. Proliferate IIoT as a subject in reputed institutes at global level with fundamental programs for basic education on the technology to be included at elementary levels and Coordination between Education, Research, and Industry by mapping the trends, demands, technology development and costs for IIoT initiatives.
    d. Setup and support multidisciplinary centers, networks, user facilities for IIoT research.
    e. Global Standards for IIoT in consonance with international standards for production and Industry incentivization for innovation in IIoT solutioning to surge competition.

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BIOGRAPHIES OF AUTHORS

Rituraj Patil,
Master of Management Studies,
A. C. Patil College of Engineering and Management,
Kharghar, Navi Mumbai, MH, India
Email: rtpatil@acpce.ac.in