Manufacturing – Opportunities for Innovation

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1. INTRODUCTION

In a global economy, countries across the world compete to gain market share of the manufacturing sector. For a country and for an organization, productivity in manufacturing is an important measure that determines its prospects for growth and its ability to compete globally. Productivity, which is a measure of output compared to input, could be improved by the introduction of digital technologies such as Industrial Internet of Things (IIoT). A leading management consulting firm estimates the value from the Internet of Things will arise chiefly from productivity improvements through equipment maintenance, inventory optimization, energy savings and labor efficiencies[1]. This paper discusses the role of IIoT in improving productivity in manufacturing.

2. IMPACT OF IIOT ON PRODUCTIVITY – INFERENCE BASED ANALYSIS

As per Moore's law (higher circuit density at reduced cost), the cost of MCU (microcontroller unit) and platforms (cloud-based, scalable, highly available, distributed solution) will keep falling, which will reduce expenses. The availability of financially viable sensors, software and devices (modules and gateway) enables manufacturers to sense more, analyze more and generate compelling business value. Additive manufacturing technology such as Aerosol Jet technology is providing an innovative printing solution for the production of 3D antennas and 3D sensors that are tightly integrated with underlying products such as industrial components (turbine blades, airframe struts, etc.). This technology effectively produces 3D printed electronics: It is highly agile and eliminates the need for the series of operations involved in manufacturing[2]. The output produced by this technology is driven by CAD data. Such printed sensors will enable data collection from areas that are not easy to reach. Statistical treatment of data will result in the quantification of processes and this, in turn, will assist in the discovery and elimination of inefficiencies.

The advancing technology provides an evolving platform where innovation can thrive. Use of technology will impact operational efficiencies, business models and market boundaries. Intel

[1] James Manyika, Michael Chui etal, Unlocking the potential of the Internet of Things (June 2015) accessed on 3 April 2016, http://www.mckinsey.com/business-functions/business-technology/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world

[2] The Internet of Things, Accessed on 12 June 2016, http://www.optomec.com/printed-electronics/aerosol-jet-core-applications/internet-of-things/

already has wins to show[3]. In one of its factories, Intel installed sensors on equipment known as CPU assembly modules, which complete the final steps of manufacturing. Using analytics software, sensors and gateways, Intel reduced the number of machine failures and boosted assembly line uptime and productivity. In addition, leveraging image analytics to detect defects on the assembly line, Intel reduced time and inspection effort by 90 percent.

Examples of current and future scenarios of the fundamental impact of disruption brought about by IIoT include:

- Traditional product manufacturers are evaluating outcome-based models. Siemens AG has designed a train-monitoring solution enabling Renfe (the Spanish national railway company) to deliver outcome-based service. Such changes will impact the service and capital expenditure parameters required to determine productivity.[4]
- Traditional roles played by manufacturers are expanding. For example, John Deere has shifted from tractor manufacturer to farming partner, leveraging IIoT. John Deere is an incumbent in the tractor market, but it was not a player in the crop assurance/farm state sensing market.
- The intelligence gathered from machine usage and past maintenance data could be used to prepare a JIT (Just-in-time) supply chain. A JIT supply chain could bring the spare requirement to near zero. The manufacturer could participate in JIT by supplying the product to the destination as and when it is required. For example, Zara has implemented radio-frequency identification (RFID) tracking of inventory and expects to complete the shift to wireless inventory in 2016[5].
- Aggregation and analysis of data across a product's life cycle can increase the uptime of production machinery, reduce time to market and gain further insights from buyer behavior[6].
- Capital expenses could be reduced by dynamically sharing data with the finance organization enabling them to provide floating rate loans or incentives for capital usage, leading to usage-based insurance of the assets.

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[3] Tata Consultancy Services, Internet of Things: The Complete Reimaginative Force (July 2015), accessed 20 March 2016, http://www.tcs.com/SiteCollectionDocuments/White%20Papers/Internet-of-Things-The-Complete-Reimaginative-Force.pdf

[4] Data analytics for smart railways, Accessed on 12 June 2016, http://www.thehindubusinessline.com/opinion/data-analytics-for-smart-railways/article8442289.ece (April 2016)

[5] Brian Hartmann, William P. King, and Subu Narayanan, Digital manufacturing: The revolution will be virtualized (August 2015), Accessed on 12 June 2016, http://www.mckinsey.com/business-functions/operations/our-insights/digital-manufacturing-the-revolution-will-be-virtualized

[6] John Nanry, Subu Narayanan, and Louis Rassey Digitizing the value chain(March 2015), Accessed on 12 June, http://www.mckinsey.com/business-functions/operations/our-insights/digitizing-the-value-chain

- Real-time pricing simulations leveraging actual factory data can drive differential product pricing based on predictions of new product quality.
- New designs, eliminating human exposure to dangers, are possible to address the challenges of production in unsafe environments, such as areas containing hazardous gases or the risky setting of underground mining. Such fundamental changes in design present opportunities to improve strategic capital expenditure decisions.

Furthermore, innovation in different domains of the IIoT will indirectly benefit manufacturers. The introduction of fitness and healthcare devices on the shop floor could help in monitoring the health of employees. The smart devices (e.g. spray masks or helmets) could enhance the safety of the worker. Energy management, facility monitoring solutions and quality management solutions could further increase efficiency.

IIoT will have an indirect effect on economies. Unlike a conventional product where enhancing the utility requires physical changes, the cyber element of the product can keep the machine up-to-date longer. Any device having a cyber element could be updated with the new version of software or firmware. Today, if we roll out a medical device that measures pulse rate, tomorrow the cyber element of the product can be upgraded with new software that complies with new data collection regulation and thus increases the utility of the product. The rate of depreciation will also change. The cyber element will depreciate at a faster rate, driving ongoing investment to continue to advance technologically[2]. This will compel companies to keep investing in the IIoT, bringing indirect value to the economy as computerization did in the latter part of last century[7].

3. IIoT Impact Based on Experience

While discussing digital strategy with manufacturing firms, it has been observed that IIoT solutions help manufacturers increase productivity by adopting empowerment, intelligence and automation into their business operations.

Productivity is generally defined as the relation between output and input. As recommended by Stefan Tangen, the exact definition of productivity must be articulated by the industry[8]. For this article, with its technology focus, the definition of productivity could be considered as follows[9]:

$$Productivity = \frac{Output}{Input\ (Capital + Labor + Energy + \ Material + \ Services)}$$

[7] Roger W Ferguson, Technology, Macroeconomics, and Monetary Policy in the United States (December 2000), accessed 28 March 2016, http://www.bis.org/review/r001212b.pdf

[8] Stefan Tangen, Understanding the concept of productivity (2002), accessed on 6 April 2016, http://www.aipa.ca/wp-content/uploads/2013/11/pap_Tangen2002-UnderstandingTheConceptOfProductivity.pdf

[9] OECD, Measuring Productivity OECD Manual, (2001), accessed 5 April 2016, https://www.oecd.org/std/productivity-stats/2352458.pdf

The following paragraphs link productivity input and output factors to empowerment, automation and intelligence.

3.1 Empowerment

With the evolution of digital technologies, stakeholders are being empowered with information. Highly accurate sensors, devices with the ability to sustain extreme conditions and better connectivity options (i.e., AllJoyn®, Bluetooth® low energy (BLE), Thread) improve information availability. In the future, the evolution of such technology enabling real time communication among humans and machines will result in enhanced decision-making speed and implementation of these decisions, increasing productivity. The workplace will be reimagined as machines, BOTs (automated or semi-automated tools that carry out repetitive and mundane tasks) and machine operators will interact in real time. Operators can work from anywhere without physical boundaries.

A Tata Consultancy Services (TCS) Survey report[7] points out that organizations have already started reaping the benefits of empowerment. To illustrate, the report mentions increased productivity in GE plants, with incorporation of mobile technology into SCADA systems. The new technology empowered managers to continually monitor equipment and processes. This dramatically improved the ability to solve problems while realizing a cost savings of more than 20 percent[10].

The productivity and cost gains generated through "smart" device monitoring and adaptation are projected to create $1.1 trillion to $2.5 trillion in value in the health care sector and $2.3 trillion to $11.6 trillion in the global manufacturing sector, by 2025[11].

3.2 Intelligence

In an industrial environment, an IIoT solution could introduce intelligence in multiple areas or locations. This could include real time intelligence at the edge, in addition to regular, immense computing power available in the cloud.

Insights in real time will enable business managers to make proactive, informed decisions to effectively control emergency or near-emergency situations. Timely actions that tackle possible breakdowns or bottlenecks will result in optimization of processes which, in turn, will increase productivity by increasing output.

[10] Tata Consultancy Services, Internet of Things: The Complete Reimaginative Force (July 2015), accessed 20 March 2016, http://www.tcs.com/SiteCollectionDocuments/White%20Papers/Internet-of-Things-The-Complete-Reimaginative-Force.pdf

[11] Adam Thiere, Andrea Castillo, Projecting the Growth and Economic Impact of the Internet of Things (June 2015) accessed on 10 June 2016, http://mercatus.org/publication/projecting-growth-and-economic-impact-internet-things

Further, batch intelligence will provide an ongoing mechanism to improve operations and dynamically set new standards and benchmarks. By leveraging machine learning/Artificial Intelligence with historical data, analytical models can be made highly precise and relevant. This helps accurately and proactively control and detect mean time of failure, providing adequate time to act in an economical way, reducing downtime and unplanned outages. This assists in maintaining the uptime and, thus, planned output.

3.3 Automation

Reducing dependencies on human intervention to run day-to-day operations will enhance the pace and quality of operations. The human capital now available from the reduced dependencies can be directed to other higher value-creating processes and functions. Intelligence at the edge will require decisions based upon predefined models. For example, on an assembly line, a scanner could read the bar code of a finished product and alert the packing station to adjust the length of the robotic arm. Such automation will reduce costs by saving energy, scrapped material and human effort. It will also speed up production and increase output. Thus, automation will positively impact productivity.

The combined effect of intelligence, empowerment and automation will increase productivity. A linkage of these factors to productivity is shown in the Figure 1.

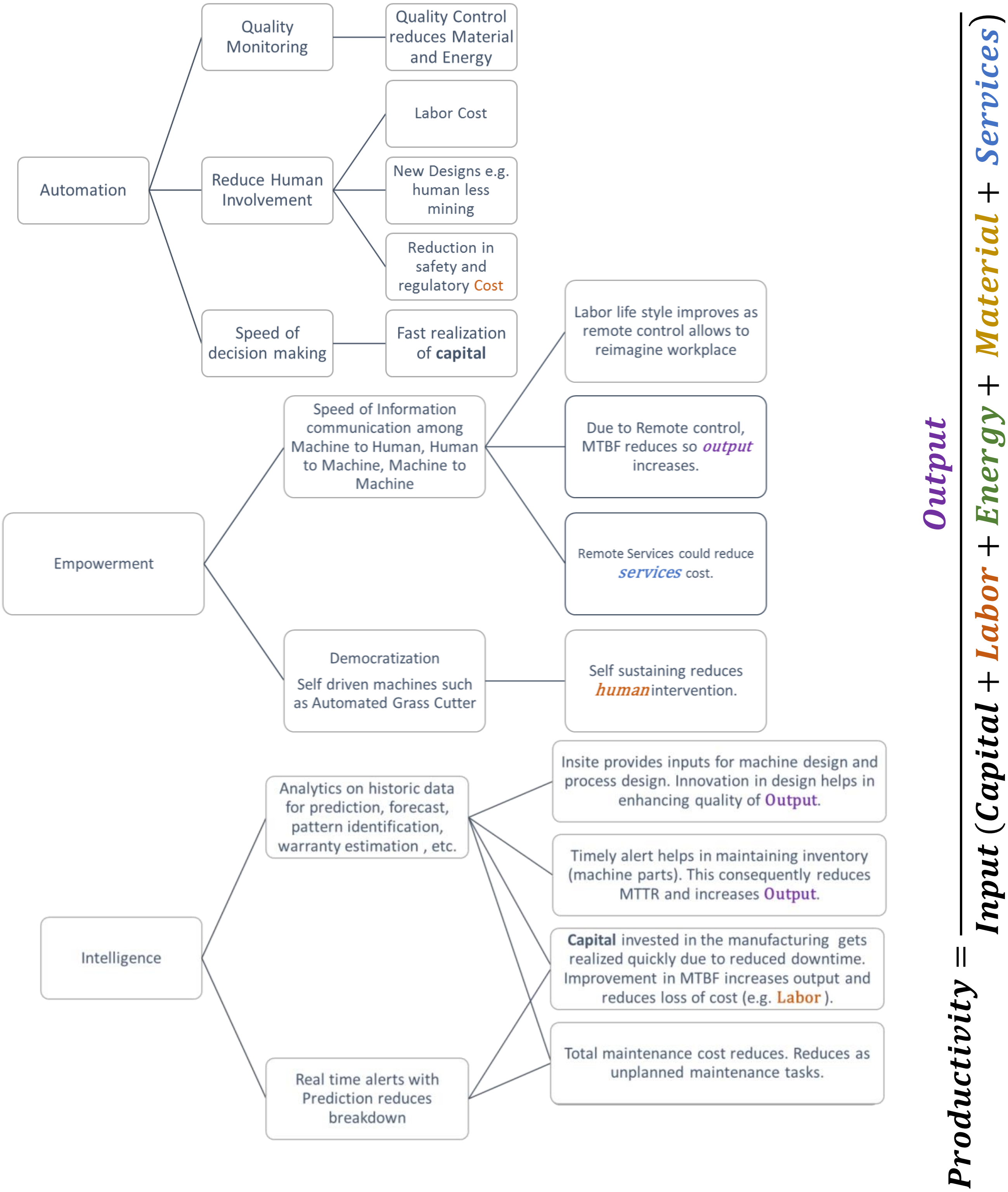

Figure 1: Linkage of Intelligence, Empowerment and Automation to Productivity

4. USE CASES

The following use cases capture how these IIoT application themes relate to any IIoT disruption.

4.1 Controlled Ambiance as a Service

Industrial manufacturers are transforming their business models from product-centric to outcome-centric in order to gain competitive advantage. This shift to a more mature level enables customers to pay for only the value and nothing else. “Controlled ambience as a service” is one such example for industrial environment HVAC needs. Ambience-regulating vendors will have visibility into physical atmosphere needs of the workplace along with past consumption levels and associated risk events. This business model could be highly relevant to environment-sensitive workplaces such as underground mining, drug research and development and oil refineries. For instance, in the underground mining workplace, ensuring ambience parameters in the control range is of utmost importance. A slight change in properties such as coal dust ratio (combustible environment), Oxygen/Nitrogen/CO concentration (worker safety), etc. could create severe, damaging outcomes. A deviating dataset received by an automated control system would respond by spraying rock dust or activating ventilation fans respectively, to re-attain the safe, prescribed limits. These data points (historical as well as real time) backed by deep analytics, will empower the vendor to “intelligently” own the accountability to keep the system up and running. This ensures enterprise ambience is maintained in accordance with predefine levels. This will enable the organization to satisfy the core need: a controlled and safe workplace. On the other hand, enterprises will be freed from owning the physical hardware which was never their core competency, empowering them to pay only for the outcome.

4.2 Proactive Quality Assurance

In a typical industrial scenario today, the quality approach followed is reactive rather than proactive. This often leads to rework and a high level of rejections, increasing costs and hampering productivity.

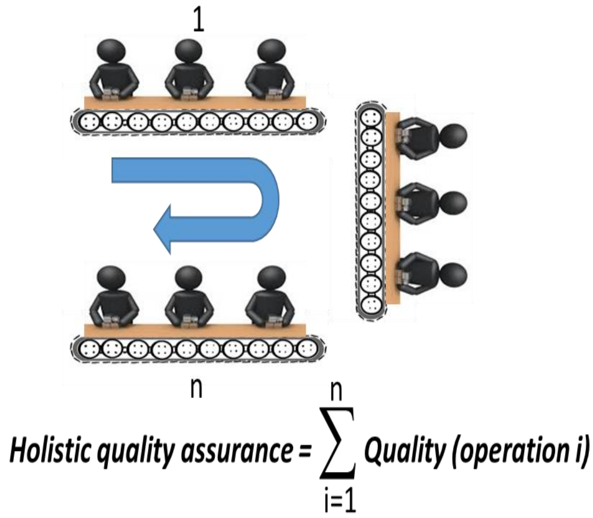

Figure 2: Quality Assurance in Manufacturing Process

Devices, embedded with sensors and inbuilt connectivity provisions, capture and transmit operational and health data. These datasets could be about raw material properties (i.e., initial moisture/stress levels), equipment health (i.e., vibration level, pressure leakages, torque, pressure generated vs. power consumption, nozzle pressure, coolant spread), tool alignment/sharpness and/or operating conditions (i.e., temperature, humidity, gas composition, pressure fluctuation). These data elements impact the product quality and were not considered earlier for quality assurance, thereby "empowering" quality engineers with valuable operational quality insights. Leveraging predefined analytical models (i.e., abnormality detection, remote fault diagnosis) will enable "intelligent" proactive quality monitoring which will lower costs by reducing rework on the parts and controlling rejections. Further, this near real time data from assembly lines spread across geographies helps dynamically update centralized rule repositories to keep a precise and "automated" eye on quality parameters.

5. CONCLUSIONS

The industrial marketplace has initiated investment in IIoT, resulting in significantly higher productivity achieved through higher operational efficiencies. However, this is just the tip of iceberg. With this momentum continuing, markets will witness highly matured operating models. With minimal infrastructure investment, these models will result in harvesting significant incremental value. The compelling value derived from the amalgamation of Empowerment, Intelligence and Automation will increase industrial output through precisely addressing objectives with better quality. At the same time, this union will reduce industrial inputs through lower rework and rejection, infrastructure costs and depreciation rates.

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