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# LEVERAGING THE INTERNET OF THINGS (IOT) FOR PERFORMANCE IMPROVEMENT IN CHINESE MANUFACTURING FIRMS: A STRATEGIC APPROACH

**LIU HUIYAN**
Research Scholar, Lincoln University College, Malaysia.

**ABHIJIT GHOSH**
DEAN, Lincoln University College, Malaysia.

**Abstract**

This research paper aims to explore how Chinese manufacturing firms can strategically leverage the Internet of Things (IoT) for performance improvement. The IoT has revolutionized the manufacturing industry by enabling real-time data collection, connectivity, and automation. However, the successful adoption and implementation of IoT technologies require a strategic approach that aligns with the specific needs and goals of Chinese manufacturing firms. This study investigates the strategic considerations and challenges associated with IoT adoption in the Chinese manufacturing sector. The research methodology comprises a mix of qualitative and quantitative methods, including case studies of IoT implementation in Chinese manufacturing firms, interviews with industry experts, and surveys with managers and employees. The findings of this study will provide valuable insights into the key factors that drive successful IoT adoption and performance improvement in Chinese manufacturing firms. The results will be beneficial for manufacturing managers, policymakers, and researchers in developing effective strategies and guidelines for incorporating IoT technologies to enhance productivity, efficiency, and competitiveness in the Chinese manufacturing industry.

**Keywords**: Internet of Things, IoT, Chinese manufacturing firms, performance improvement, strategic approach, data collection, connectivity, automation, qualitative research, quantitative research.

## INTRODUCTION

The manufacturing industry has a significant impact on the economy of the United States, with a gross production of $2.2 trillion in 2016, accounting for 11.7% of the overall GDP of the United States. In order to gain a competitive edge in global marketplaces, contemporary manufacturing businesses are always working to develop new goods (or services) that have outstanding characteristics such as adaptability, flexibility, responsiveness, quality, and dependability on an unprecedented scale. The introduction of brand new items has turned into a fundamental and necessary component of modern living. For instance, mobile phones and autos are transitioning from only being communication and transportation devices to also functioning as personal gadgets as a result of being integrated with additional services. Products are getting smarter and smarter about themselves. Because of this, production systems are growing more complicated, and as a result, manufacturers are turning to more advanced sensing technologies in order to improve the information visibility and system controllability of their operations. Notably, Industry 4.0 is motivating businesses that manufacture goods to evolve into a new generation of cyber-physical systems and move in the direction of

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network-enabled smart manufacturing. The degree of "smartness" is dependent, to a large extent, on data-driven innovations that "enable all information about the manufacturing process to be available whenever it is needed, wherever it is needed, and in an easily comprehensible form across the enterprise and among interconnected enterprises" The "smartness" level is determined by the degree to which these innovations are implemented. The usage of a large number of networked devices to carry out manufacturing activities is becoming increasingly common as "smart manufacturing" becomes a trend that has an influence on the expansion of businesses and the economy. Some of these machines depend substantially on the output produced by other machines, such as in the case of a pipelined product line, while others may perform the same or different duties or jobs. It is also possible to dynamically adjust the connection between devices that are networked in order to achieve more adaptability and flexibility in the completion of specialised activities. As a consequence of this, the intelligent synergy of machines that are connected via a network is essential to enhancing the performance of industrial systems. The Internet of Things (IoT), which is the construction of a worldwide information network made of a huge number of interconnected "Things," is a vital enabling technology for smart manufacturing. Smart manufacturing is the process of making products using information and data collected from physical objects. Materials, sensors, actuators, controllers, robots, human operators, machines, equipment, products, and material handling equipment are just few examples of the "Things" that may be produced at this stage of the manufacturing process. The architecture of the internet of things (IoT), which is based on the internet, offers a once-in-a-lifetime chance to link the "Things," services, and applications used in manufacturing to achieve successful digital integration of the whole manufacturing industry. This integration can be expanded to include manufacturing execution systems (MES), process control systems (PCS), supply chain management (SCM), and enterprise resource planning (ERP). Despite this, the increasing expansion of IoT sensing at large scales results in the generation and manifestation of vast amounts of data, which may be kept locally or in data repositories that are dispersed throughout the cloud. For the full potential of big data to be realised in smart manufacturing, fundamentally new approaches for managing large-scale Internet of Things (IoT) data, analysing information, and controlling manufacturing processes are required. For instance, the Internet of Things may make use of a large number of sensors to carry out ongoing monitoring of the state of a machine and then upload the resulting data to the cloud. Not only do IoT data consist of previously gathered sensor signals and measurements from a vast number of equipment, but they also comprise real-time information gathered via in-situ monitoring of those units. The data may be readily downloaded from the cloud platform and sent to distributed computers for parallel processing. This can then be utilised to extract helpful information and prototype algorithms for deployment in the cloud or in IoT "Things." However, relatively little effort has been done to develop new approaches and tools for manufacturing system diagnostics, prognostics, and optimisation that harness sensor data, also known as machine signatures, from a large-scale Internet of Things network of machines. In order to achieve high degrees of autonomy and optimisation of manufacturing firms, smart

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manufacturing goes beyond the automation of manufacturing shop floors and instead relies on data-driven innovations. The physical world is reflected in cyberspace through data-driven information processing, modelling, and simulation as a result of the Internet of Things (IoT) and big data initiatives, which are leading to the realisation of cyber-physical manufacturing systems. Analytics in cyberspace make use of the information and knowledge gained from data to determine the most effective courses of action (or control systems), which are then sent back into the actual world. Integration and interaction of cyberspace and the physical world are essential to the realisation of smart manufacturing. The purpose of this article is to provide an overview of Internet of Things technologies and systems that are enabling data-driven advances in smart manufacturing. The internet began as hard-wired computer networks and has since progressed to wireless human networks, and now it has entered a new phase in which it is comprised of smart and linked networks of manufacturing things. This development, when combined with recent breakthroughs in areas like as big data analytics, virtual reality, and cloud computing, has the potential to usher in a new paradigm for smart manufacturing. In this paper, we describe a new architecture for the development of a virtual machine network that makes use of the Internet of Things (IoT) and cloud computing. We have also examined the concerns regarding the Internet of Things' (IoT) cybersecurity that are of the utmost significance to organisations and operations, as well as the Internet of Things and smart manufacturing rules that governments all over the globe have developed for the future of smart factories. In conclusion, both potential and difficulties associated with IoMT are discussed. To improve the Internet of Manufacturing Things (IoMT) technology, it is our hope that the work presented here will serve as a catalyst for enhanced research efforts across several disciplines and more in-depth investigations.

## OBJECTIVE

i) To understand the strategic knowledge management.

ii) To examine the effect of knowledge management strategy on manufacturing firm.

## IOT OVERVIEW

### The Evolution of the Internet

The reach of the Internet and the connection it provides have affected every sphere of human activity. According to some estimates, around 47 percent of the world's population used the internet in 2015. The progression from the days before the internet to the present-day Internet of Things is seen in Figure 1. In the era before the internet, advancements in communication ranged from Innocenzo Manzetti's idea of a "speaking telegraph" in 1844 through Alexander Bell's first phone call from New York to Chicago in 1892 to the blossoming mobile and smart phone technologies of today. The United States Department of Defence provided funding for the ARPANET project in the year 1960. This project was tasked with developing the first prototype of the Internet, which consisted of

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interconnected computer networks for error-tolerant communications. The globe witnessed fast development of content materials in the internet beginning in the 1960s and continuing through the 1990s. These advancements included emails, information, entertainment, web surfing, and HTML webpages. After the 1990s, the internet began to provide an increasing number of services to individual users as well as commercial users. These services include online auctions, commerce, shopping, ads, search, and financial transactions. Since the beginning of the 21st century, social networking platforms like Linkedin, Facebook, and Twitter have made it easier for billions of individuals to communicate with one another. In addition, websites that provide massive open online courses (MOOCs) are becoming increasingly important in developing an internet of students for the purposes of teaching and education. The internet of people has given way to the internet of things, and we have lately been able to see this transition. The number of "smart" gadgets that are connected to the internet continues to rise. There will reportedly be 212 billion "things" connected to the internet by the year 2020, according to estimates.

In addition, the manufacturing sector is moving towards the new "smart factory," which is envisioned as a cyber-physical system that "enables all information about the manufacturing process to be available when it is needed, where it is needed, and in the form that it is needed across entire manufacturing supply chains, complete product lifecycles, multiple industries, and small, medium, and large enterprises". This new "smart factory" is expected to revolutionise the manufacturing sector.

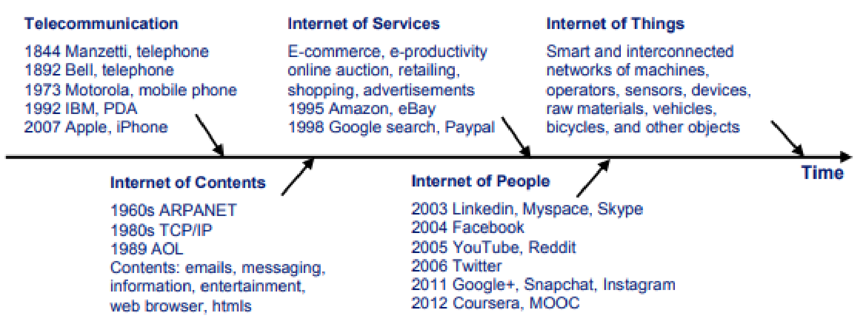


**Figure 1: The Development of the Internet over Time**

## IOT SENSING

In 1999, Ashton, working at the MIT Auto-ID Centre, is credited with being the first person to conceptualise the Internet of Things. The construction of a "Internet" made up of a vast number of interconnected "Things" is what is meant by the phrase "Internet of Things." When used in this context, the term "Internet" refers to a worldwide inter-networking infrastructure that makes use of the TCP/IP protocol to connect "Things" and allow for their remote control. A combination of low-level wired and wireless technologies, such as Ethernet, Wi-Fi, Bluetooth, ZigBee, radio frequency identification (RFID), or barcodes, might provide support for high-level communication that is based on the TCP/IP suite. "Things" refers to any things (either physical or virtual) that are capable of sensing,

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collecting, and/or exchanging data regarding environmental and operational dynamics. "Things" can be either physical or virtual. Vehicles, sensors, actuators, machines, controllers, robots, and human operators are all types of "Things" that may be found in the world. In actuality, the IP address and/or a universally unique identification (UUID) are typically utilised when referring to a "Thing." This classification significantly improves the identifiability of "Things," which in turn makes it much simpler to incorporate "Things" into large-scale Internet of Things networks. RFID, wireless sensor networks (WSN), and mobile computing are some of the most important technologies that contribute to the integration of "Things" into IoT ecosystems. These technologies are briefly covered in the following sections: Radio frequency identification, or RFID, is a technology that can automatically identify, monitor, and track an object by reading and querying RFID tags that are affixed to the object RFID technology is comprised of several fundamental elements, the most fundamental of which are RFID tags, RFID readers, and backend signal processing and IT infrastructure. The radio frequency identification (RFID) tag has an antenna that can receive and transmit data to and from the reader, as well as a tiny microprocessor that can process information and store it on its own. RFID tags can either be passive or active, depending on the user's needs. The energy needed to power passive tags comes from the reader's radio waves. Active tags are those that have an internal power source (such a battery), allowing them to function at a greater distance from the reader than passive tags. RFID readers are devices that send out an encoded interrogation signal to all of the tags that are within range and then read the information that is contained on those tags. The tags, in contrast to barcodes, need simply be within the range of radio waves to be read; they do not need to be inside the line of sight. Radio waves serve as the energy source for passive tags, allowing the tags to reply with the identifying information that has been stored within them. Because active RFID sensors are equipped with their own built-in batteries, they often have a greater communication range than their passive counterparts. For instance, high-frequency active tags (e.g., 3-10GHz) can reach ranges from 300 feet to 1500 feet, but low-frequency passive tags (e.g., 800MHz-900MHz) often work at ranges ranging from 1 foot to 50 feet. These differences in range are due to the difference in frequency. RFID systems are often divided into one of three groups, namely Active Reader Passive Tag (ARPT), Active Reader Active Tag (ARAT), and Passive Reader Active Tag (PRAT). These categories are named after the types of tags and readers that are used in the system. RFID has a number of benefits, including cheap cost, battery-free operation, great range, and long lifetime, among other advantages. It is important to note that RFID systems have been utilised extensively in the operations of industrial enterprises, particularly for the tracking of work-in-process, inventory control, and supply chain visibility management.

**Table 1: Income**

| | |
|---|---|
| Income | <20000 (M= 87, F= 103) |
| | <21000-30000 (M= 129, F= 51) |
| | <31000-40000 (M= 81, F= 66) |
| | <41000 (M=93, F= 74) |

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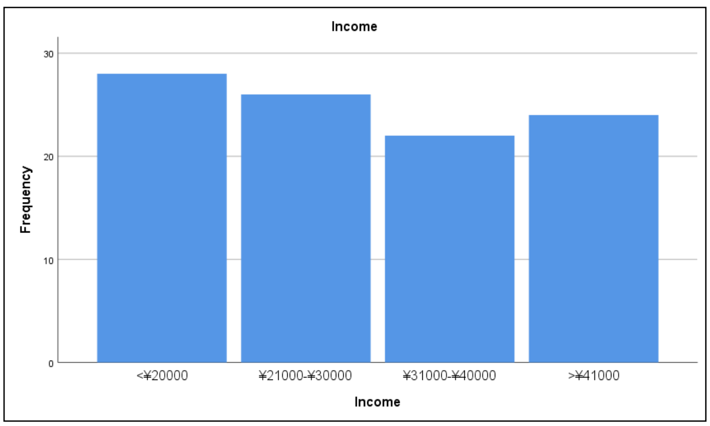
In the study data comprised of individual income less than 20000 (N=190, M= 87 & F= 103), 21000-30000 (N=180, M= 129, & F= 51), 31000-40000 (N=147, M= 81, & F= 66), and more than 41000 (N=167, M=93& F= 74) respectively.

**Table 2: Income percentage**

| Income | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | **<¥20000** | 192 | 28.0 | 28.0 | 28.0 |
| | **¥¥-2100030000** | 178 | 26.0 | 26.0 | 54.0 |
| | **¥¥-3100040000** | 151 | 22.0 | 22.0 | 76.0 |
| | **>¥41000** | 164 | 24.0 | 24.0 | 100.0 |
| | **Total** | 685 | 100.0 | 100.0 | |

**Figure 2: Income Chart**




According to the findings, 685 people participated in the survey. 28 percent of the applicants had an annual income of more than Rs. 20,000. Researchers have 26 percent of the applicants in the Rs. 21000 - 30000 range. Researchers have 22 percent of applicants in the Rs. 31000 - 40000 range. Researchers have around 24 percent of the total number of applicants in this category, totaling 41,000.

**Table 3: Technical skills**

| | |
|---|---|
| Technical Skills | Beginner (M= 89, F= 55) |
| | Average (M= 103, F= 62) |
| | Proficient (M= 75, F= 82) |
| | Expert (M= 123, F= 96) |

In the study data comprised of technical skills of Beginner (N=144, M= 89, & F= 55), Average (N=165, M= 103, & F= 62), Proficient (N=157, M= 75, & F= 82), and Expert (N=219, M= 123, & F= 96).

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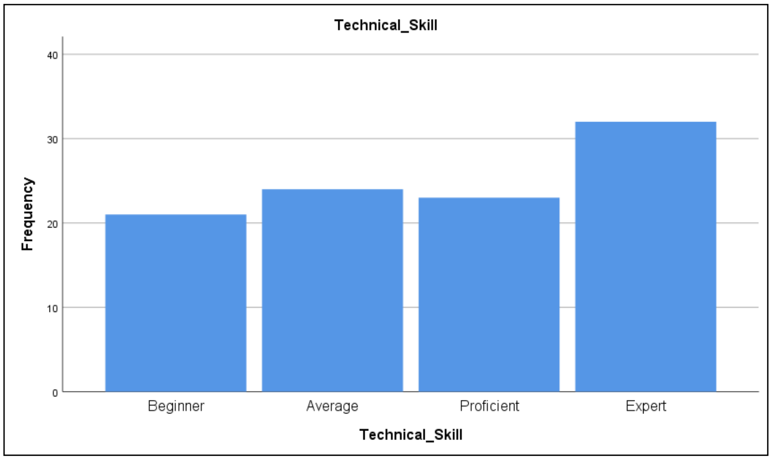
**Table 4: Technical Skill Percentage**

| Technical Skill | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Beginner | 144 | 21.0 | 21.0 | 21.0 |
| | Average | 164 | 24.0 | 24.0 | 45.0 |
| | Proficient | 158 | 23.0 | 23.0 | 68.0 |
| | Expert | 219 | 32.0 | 32.0 | 100.0 |
| | Total | 685 | 100.0 | 100.0 | |

**Figure 3: Technical skill chart**




This graphic shows that 21 percent of candidates are Beginners, 24 percent are Average, 23 percent are Proficient, and 32 percent are Expert in the research, which garnered 685 answers.

**Table 4: Computer skill**

| | |
|---|---|
| Computer knowledge | Beginner (M = 68, F= 61) |
| | Average (M= 89, F= 55) |
| | Proficient (M= 110, F= 96) |
| | Expert (M=123, F= 83) |

In the study data comprised of computer knowledge of Beginner (N=129, M = 69, & F= 61), Average (N=145, M= 89, & F= 55), Proficient (N=206, M= 110, F= 96), and Expert (N=206, M=123, F= 83).

## CONCLUSIONS

The manufacturing industry is always working to develop new goods and services in order to get a competitive advantage in the international market. As a direct consequence of this, cutting-edge sensor technologies are increasingly being included in industrial systems in order to boost the information visibility and system controllability of these systems. It is important to keep in mind that even if sensors, data, and IT systems could already be accessible in physical factories, they are not yet tightly connected to the level

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of the internet of things (IoT). In recent years, an initiative known as Industry 4.0 has been developed with the objective of bringing the production system into the fourth generation of cyber-physical systems for smart manufacturing. Sensing capabilities of the Internet of Things capture massive volumes of data from industrial systems located in the real world. For the Internet of Things (IoT) to reach its full potential in smart manufacturing, significant advancements in analytical approaches are required. The questions that need to be answered presently are, "How can data-driven information processing and modelling be used to reflect physical manufacturing in cyberspace?" and "how can the useful information and knowledge that can be extracted from data be exploited to provide better manufacturing operations in the physical world?" In point of fact, data-driven innovations are very essential to the successful realisation of smart manufacturing in order to achieve seamless integration of cyber and physical worlds. Companies within an industry, as well as trade bodies and standard-setting organisations, are competing against one another to take the lead in the development of Industry 4.0. To define the communication structure of Industry 4.0, a variety of Internet of Things architectures, such as RAMI 4.0 and OPC UA, have been presented as potential solutions. Note that RAMI 4.0 offers a reference architectural model to define the three most important aspects of the fourth industrial revolution in manufacturing, which are the Factory Hierarchy (which includes product, field device, control device, station, work centre, and enterprise), Architecture (which includes Asset, Integration, communication, information, function, and business), and Product Life Cycle (which includes everything from the initial design to the scrapyard). Additionally, commercial Internet of Things systems such as GE Predix, ThingWorx, IBM Watson, Microsoft Azure, and Amazon AWS are widely accessible to enable physical "Things" and cyber-world applications to interact with each other and integrate with each other. The proliferation of different kinds of Internet of Things architectures and platforms is beneficial to the quickening of the development of Internet of Things systems.

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