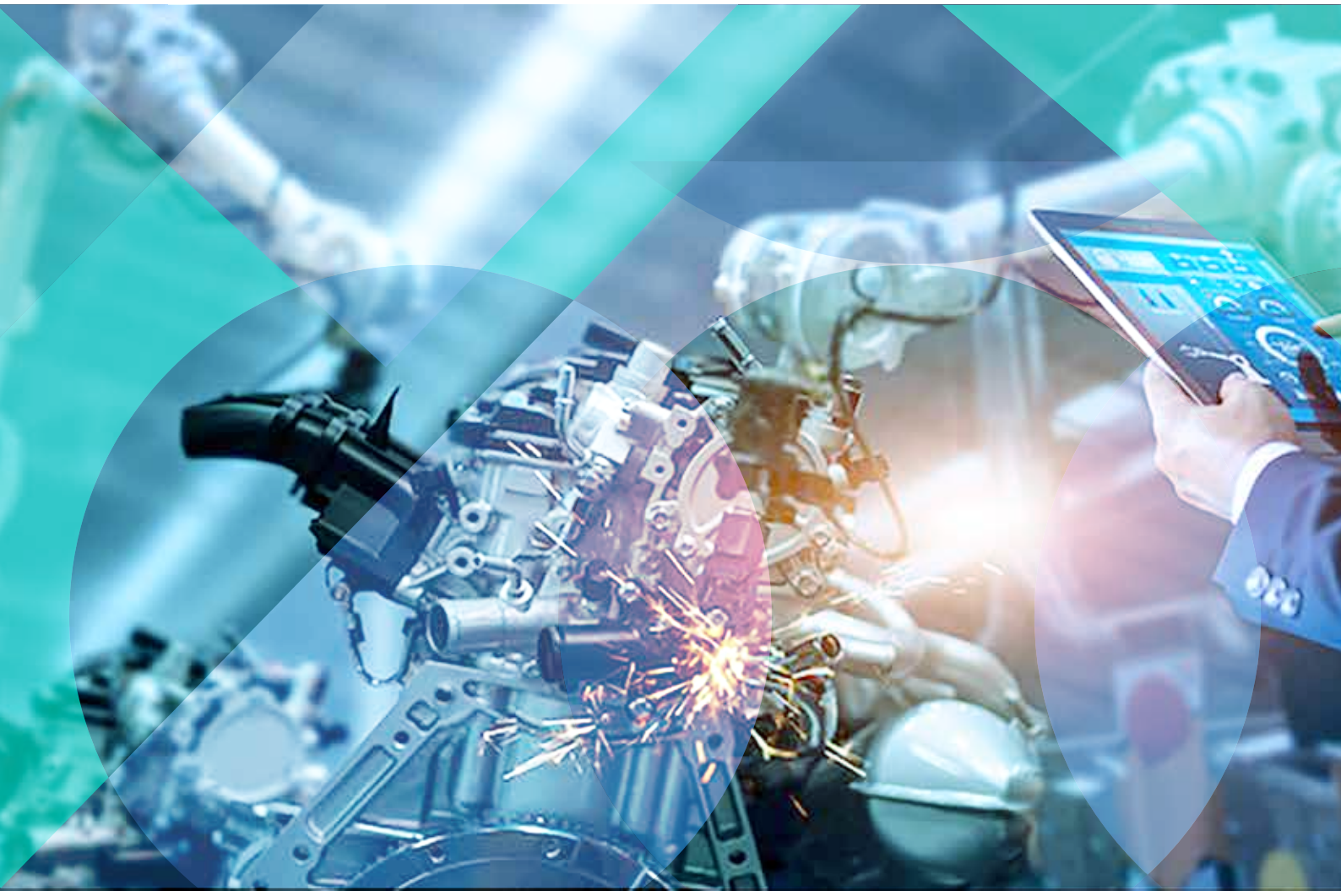
TRANSFORMING MANUFACTURING

CASE STUDIES IN SELECTED
APO MEMBER COUNTRIES



The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the National Productivity Organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 member countries.

APO members
Bangladesh, Cambodia, Republic of China, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkey, and Vietnam.

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Case Studies in Selected APO Member Countries

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CONTENTS

FOREWORD

Rapid advances in new-generation technologies, together with changes in the overall environment, have affected global production systems. Technological changes are reshaping the ways manufacturers strategize to take advantage of new economic opportunities. In the APO region, even though the impact varies by company size, sector, maturity level, leadership, etc., all manufacturers need to adapt to stay competitive in global value chains and overcome the challenges of increased supplier–partner relationship complexity, greater competition, and other uncertainties related to the current COVID-19 pandemic.

Continuous improvement and transformation are necessary to ensure adaptive capability and business competitiveness. Various approaches have been taken by manufacturing firms to adapt and find ways to differentiate themselves. A study on Transforming Manufacturing: Case Studies in Selected APO Member Countries was conducted by the APO to analyze strategies for sustaining business growth and processes for maintaining continuous improvement in the era of Industry 4.0. The cases presented in this publication show that there is no single strategy to fit all manufacturing enterprises and no common formula for success. The analyses demonstrate not only the results of transformation strategies but also the rationales behind the processes adopted.

The APO hopes that the case studies and analyses in this publication will provide useful information on strategic thinking processes for industrial transformation by manufacturers. The efforts and commitment of all the experts who participated in the research are very much appreciated. The APO would also like to thank the companies who agreed to serve as case studies and provided valuable data and support.

Dr. AKP Mochtan
Secretary-General
Asian Productivity Organization
Tokyo, February 2022

ACKNOWLEDGMENT

The idea of creating a compilation of case studies on manufacturing transformation strategies for Industry 4.0 was culminated out of various deliberations by the APO Center of Excellence on IT for Industry 4.0 hosted under the auspices of the National Productivity Council, India. Inputs provided by the Center during the coordination meeting of experts, and for the finalization of the document are valued.

Without their contribution, this publication would not have been completed.

EXECUTIVE SUMMARY

While the global environment changes rapidly with advancing technologies and unpredictable factors, such as COVID-19, transformation with resilient leadership and continuous improvement remain necessary to businesses to assure adaptive capability and competitiveness. Transformation is a dynamic process, required for continuous improvement, and transformation strategies are a set of strategic choices for goal setting and performance management that undergo the dynamic process. A successful transformation strategy is evaluated based on the achievement of planned strategic objectives (case by case), instead of using a common standard-for-all for diverse companies in the global market. Multiple case studies presented in this publication demonstrate the strategic thinking and the rationale of transformation process instead of merely reporting the results of established companies. Why did the company adopt Industry 4.0 and its transformation? What benefits were considered when considering Industry 4.0 and the accompanying manufacturing transformations or upgrades? 15 case studies from five APO member countries, showcasing different industries and resources are invaluable reference for companies that are considering their own business transformation.

The research framework was designed with the principles of innovation ecosystem and strategic development. Eight perspectives of case review and four steps of analysis were applied to the benchmarked cases accordingly. A comprehensive review of market environment factors and business operations systems is important to identify better manufacturing transformation strategies. This research project is thus designed to deliver an 'outside-in' analysis by using the proposed eight case review perspectives and 'inside-out' analysis by using four steps strategic planning.

Conclusions for each country's case studies are presented in a minimum of two subsections. One perspective is at the policy level of a nation, or regional economy, or specific industry while the other from the enterprise level to directly summarize major findings and implications from the case studies. For micro, small, and medium enterprises (MSMEs), additional subsections are provided from the entrepreneurs' perspective.

Lessons learnt from the benchmarked cases as well as major findings and implications from the selected 15 cases of Republic of China (ROC), Japan, Thailand, Malaysia, and India are summarized as follows:

i) Manufacturing transformation of companies is highly connected with their technology, process, products and services, and their business model in the target market. The transformation strategies are very adaptive and should be considered for the dynamic process of continuous improvement. In these case studies, there are relatively established

companies with mature developments, such as those in Japan and ROC. Some case studies are on SMEs and early stage transformation with Industry 4.0 concept - Thailand and Malaysia. Case studies from India represent the potentials for Industry 4.0 applications with substantial market opportunities. None of the studied projects adopted the same technology and business innovation for their transformation even though they endeavor to achieve a common goal of business growth. Each case faced its own transformation challenges and strategies. Accordingly, different policies should be considered when promoting transformation into Industry 4.0 and smart manufacturing. Further, the best business strategy for Industry 4.0 may be the 'best fit' for a company based on its size, resources, scope, and business vision perceived by the business owner and organization. Though the industries and companies may be from the same sector, the strategies may vary dramatically from one to the other.

ii) Japan's case studies highlights that its manufacturing transformation is connected to UN's Sustainable Development Goals (SDGs) and environment, social, and governance (ESG) solutions. Their manufacturing transformation may not be linked to profit creation alone, but also to the sustainability of the business ecosystem. This tendency aligns with the Japanese concept 'Society 5.0' which means the betterment of the whole society with advanced technologies. Here, manufacturers recognize themselves as members of society. They emphasize on sustainable growth of themselves as well as the betterment of the society. In this sense, manufacturing transformation is viewed as an inclusive matter, which should be considered as a socioeconomic viewpoint. In Japan, 'Society 5.0' is put forward by the cabinet. Diverse ministries from economy, technology, welfare, and education fall under this umbrella, which is one of the best practices with the concept of inclusive growth.

iii) ROC's cases focuses on the importance of an ecosystem of innovation and collaboration among government, academia, and industry to bridge the gap of technology development and application for manufacturers, especially for SMEs. Companies have risen beyond their social needs and face their esteem needs (Maslow's hierarchy of needs) with strong foundations. Located in the world-class science park in ROC, TSMC is the leading semiconductor manufacturer and has just fulfilled its esteem needs when it embarked on its Industry 4.0 journey in 2018. The company is working for its self-actualization needs by investing in artificial intelligence (AI) and big data analytics. The strategic transformation is successfully connected with technological innovation, business model, targeted market, and governmental policies.

iv) The manufacturing transformation in Thailand and Malaysia is relatively for SMEs and early stage development. Thai industries had to survive by cost reduction and productivity improvement to maintain cash flow decrease from a huge drop in sales. The Malaysian government strongly

supports the digital transformation in all business sectors and prioritizes the implementation of Industry 4.0 transformation by stages with focus on the labor-intensive industry. Even though the manufacturing transformation is at the early stage, strategic objectives and specific measures as performance over time are essential in assuring comprehensive design and implementing transformation strategies. Collaborations with leading countries, such as Japan and ROC, may benefit companies for its enhanced technology management and the utilization of international resources.

v) The government of India has taken several ubiquitous initiatives and measures in implanting the mission of self-reliant Indian nation through the mission policy 'ATMANIRBHAR BHARAT' (Self-Reliant India Mission). The aim of the policy is vocal for India's local products and to make them global. Culture of innovation and entrepreneurship are identified as critical factors that foster business and technological growth of an organization. The case studies illustrate that a company must align its business strategies with sustainable manufacturing model and adopt digitalized system in the manufacturing process, such as lean, total productive maintenance, and total employee involvement. The manufacturing transformation in India provides more incentives for business growth strategy to catch the foreseeable market opportunities and future developments.

CHAPTER 1

METHODOLOGY AND FRAMEWORK OF ANALYSIS

INTRODUCTION ON INDUSTRY 4.0 APPLICATION AND CONTEXT CONDITIONS

Industry 4.0 is defined as the fourth industrial revolution. After mechanization (Industry 1.0), mass production (Industry 2.0), and automation (Industry 3.0), now the "Internet of Things (IoT) and services" are becoming an integral part of manufacturing. Industry 4.0 technologies have the potential to create extraordinary growth opportunities and competitive advantages. Therefore, its applications are diverse and able to deliver broarder benefits to business performance.

Industry 4.0 builds upon advanced technologies that rely on data generated by digitization of things, machines, and processes. Accordingly, it is important to specify which technologies were adopted (or invented) for Industry 4.0 applications and what business functions were improved by it.

Traditional manufacturing industries are usually focused only on products and the manufacturing processes. However, with modern industrial technology readiness and fast-changing global market, technological innovations should be integrated into business models and market performance. Therefore, for Industry 4.0, manufacturing industries cannot rely on technology and manufacturing process alone, but to have a comprehensive understanding and practice of the international supply chains as global value chains [1–2].

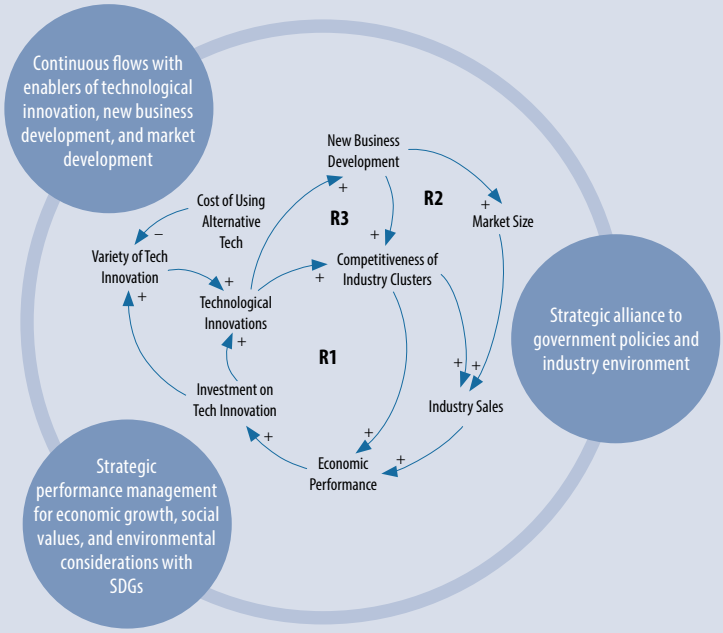
From the principle of systems and sustainable system development (SSD) for industry and innovation, technological innovations and new business model developments are the driving force of market growth and industrial economics [3–10]. In time, vibrant growth and economic performance will boost further investment into technological innovations and reinforce a feedback loop for positive development. Generally, from industry and corporate levels, two major perspectives are included in the case study for Industry 4.0 enhanced manufacturing strategies.

- First perspective - An innovation ecosystem's macro point of view at industry level, which consists of a feedback structure on technological innovations, business model development, and market performance. This is vital in guiding companies to form the bigger picture and develop a systematic strategy map for their development. Figure 1.1 shows demonstrative examples and they can be used to answer the following questions. How technological innovations, business models, and market development are connected? How government-academia-industry collaborations are performed to support the manufacturing sectors and their transformation with Industry 4.0 application? What governmental policies or industry/business environment are beneficial to the developments?

- Second perspective - Companies' business operations management system and their transformations should be considered as a continuous improvement process from the dynamic perspective. The dynamic transformation process can be systematically reviewed and/or diagnosed based on the principles and key elements of operations management system, including strategic business objectives, customer-based market competitive strategies and operations strategies, core products and services design, productivity, process selection, capacity planning, enterprise resource planning, human resource management, project management, supply chain management/collaboration, IT strategies and data analytics, etc.

FIGURE 1.1

PRINCIPLE OF INNOVATION ECOSYSTEM FOR SUSTAINABLE SYSTEM DEVELOPMENT



BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

Business strategies comprise thinking of organizational and operational strategies. Organizational strategies are focused on market competitiveness and the attractiveness of products/services to the customers while operational strategies look into the efficiency and effectiveness of the operations management systems. To have a comprehensive study of business strategies for manufacturing transformation, the benchmarked companies can be evaluated and reported through the following eight aspects with review questions. The eight perspectives provide a reference model to review a company's readiness as well as its strengths and weaknesses responding to their business strategies for Industry 4.0 and digital transformation.

A. Economic Alignment

1. What is the economic and industry environment and how the company strengthen the alignment with market demand (including customer communication channels)?

2. Does the company have a clear idea which market trends are likely to have the greatest impact on the company over the next three years?

3. Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenues and costs?

4. Are they maximizing their use of remote diagnostics, and other forms of direct feedback to improve the customer experience with their products and services?

B. Technology Utilization

1. What is the core technology innovation or adoption for manufacturing transformation and how those technologies are connected to their business functions (business model)? E.g., technologies driven by big data, AI, IoT, mobile and social computing, cloud, and other innovative technologies.

2. Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?

C. Talent Development

1. Are there any skills gap for manufacturing at different levels of employees or managers?

2. How does the company respond to the needs of human resources and talent development?

3. Does the company have an effective HR strategy for recruiting, training, and retaining the talent needed for ongoing service transformation?

D. Supply Chain Collaboration and Partnership

1. Are there any complexities or challenges caused by distributed sourcing, engineering, and production?

2. How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?

3. Does the company know how well strategy and planning is coordinated within and across their business functions to respond proactively to market trends?

4. Does the company have in place robust methods for coordinating strategy and planning throughout the organization and partner ecosystem?

E. Market Competitiveness

1. What is the identified competitive advantage in domestic and global markets?

2. What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?

3. How does the company deal with the competitors for a sustainable business model?

4. Does the company embrace a 'design, build, and service anywhere philosophy', and how do they compare to competitors' capabilities and customer expectations?

F. Innovation Ecosystem

1. Are there any external sources (from the government, academia, or industry) supporting the company's business ideas generation and innovations?

2. What is the mechanism of strategic alliance as an innovation ecosystem and how does the company collaborate with and benefit from the ecosystem?

G. Strategic Management

1. Does the company have strategic (measurable) objectives for manufacturing transformation? It can be one focused objective or normally multiple objectives from diverse perspectives (e.g., Financial Perspective - outlining the financial objectives, Customer Perspective - outlining the objectives related to customers and the market, Internal Process Perspective - outlining the internal business process objectives, Learning and Growth Perspective - outlining the objectives related to employees, culture, and information system, etc.)

2. What is the past performance over time in terms of the objectives?

3. Why the performance path in the past?

4. When is the anticipated performance supposed to take place? (e.g., next three years)

5. How will the company try to achieve the objectives of performance in the future?

6. What are the driving force/s or resources that drive the expected performance and how are they managed?

7. What are the disadvantageous factors that can hurt performance and how can they be managed?

H. Regulation of Operations

1. Are there any rising standards from environmental concerns or standards-based factors, like ISO compliance, that apply across an increasingly interconnected world?

2. What are the impacts to the company and how can the issues be resolved?

FRAMEWORK FOR ANALYZING THE RESULTS OF BUSINESS STRATEGIES

Manufacturing transformation for Industry 4.0 leads to a more diverse and dynamic development of business process and performance. An integrated framework of Simulation-based Strategic Decision Support System (SSDSS) [11–12], Knowledge-based Management Decision Support System (KMDSS) [13], and Dynamic Performance Management (DPM) [14–15] comprising "Strategy Map" from the concept of Balanced Scorecard (BSC) [16–19] and "Strategy Dynamics" (SD) [20] methodologies can be used to analyze the results of business strategies. Both quantitative and qualitative evaluations are applicable for the case studies while performance gap analysis can also be adopted for continuous improvement. The following four steps ensure a systematic cost-effectiveness analysis for implemented business strategies and the performance.

Step 1: Evaluation based on BSC strategy map for diverse performance indicators

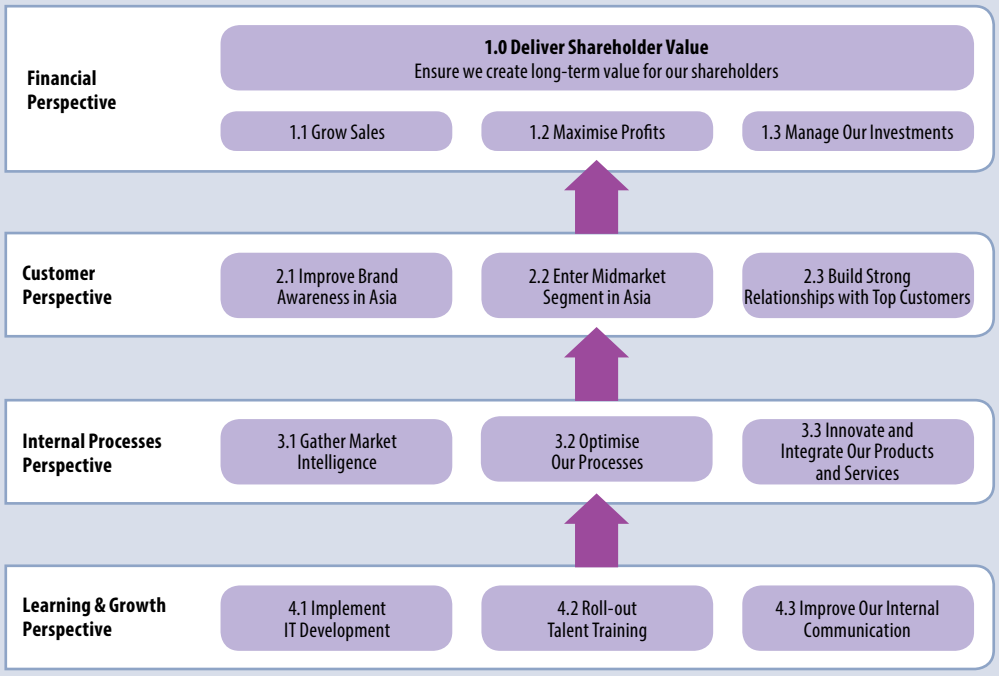
Strategically, a company can develop one focused objective or normally multiple (diverse) objectives for manufacturing transformation. From the concept of BSC, companies can develop their strategic objectives from four perspectives and integrate them into one strategic map. The four perspectives are:

- Financial - outlining the financial objectives
- Customer - outlining the objectives related to customers and the market
- Internal Process - outlining the internal business process objectives
- Learning and Growth - outlining the objectives related to employees, culture, and information system

Accordingly, the aforementioned perspectives of strategic business objectives can be first identified, if any.

FIGURE 1.2

EXAMPLE OF A BSC STRATEGY MAP



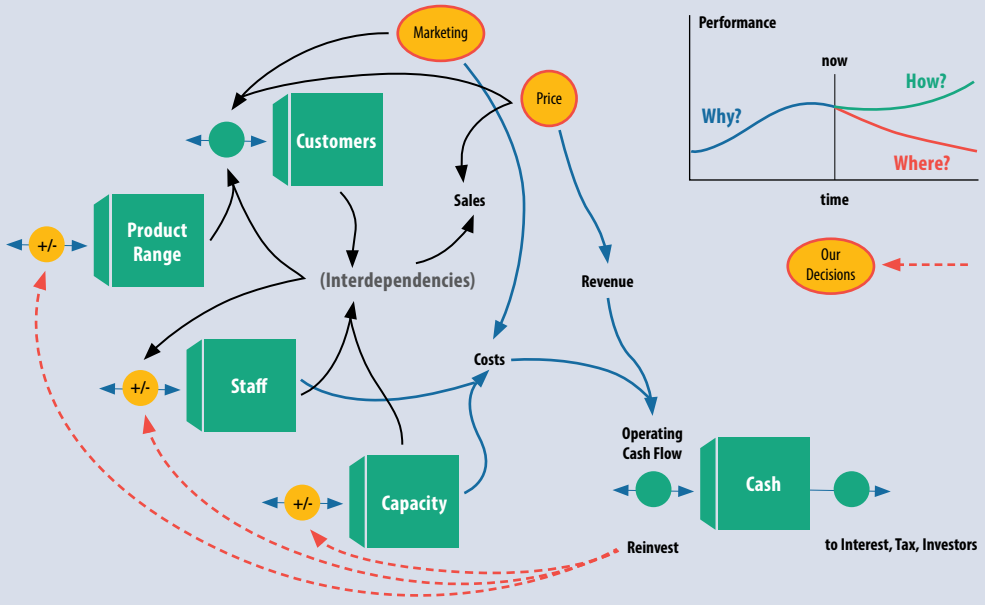
Step 2: Evaluation based on strategy dynamics for quantified performance over time

Strategy dynamics methodology focuses on quantified performance over time. The ultimate concern of strategic management is to quantitatively improve performance over time sustainably. This can apply to the enterprise as a whole, or for a key function of interest [e.g., sales]. This means answering some challenging questions:

- What was the past performance over time in terms of the objectives?
- Why is performance following its past/current path?
- Where will performance go if we continue as we are doing today?
- How can we design a robust strategy to radically improve that performance into the future?
- What are the driving forces or resources that drive performance and how are they managed?
- What are the disadvantageous factors hurting performance and how they can be managed?

FIGURE 1.3

CONCEPTUAL MODEL OF A STRATEGIC ARCHITECTURE AND PERFORMANCE OVER TIME



The trajectory that performance is following at any time depends, strongly and unavoidably, on what has occurred over the organization's history. The method therefore starts from a time chart of the organization's performance over its relevant history, and into the future, as measured by one or more conventional indicators (e.g., revenue or profits). With the performance over time chart conceptual model, stocks and flows diagram is usually adopted to present the dynamics of accumulated (or decreased) performance with the inflows and/or outflows. Connected stocks and flows for dynamic performance management with multiple business objectives will be a "Strategic Architecture" that explains and monitors any quantified key performance over time and their driving factors, as shown in Figure 1.3.

Step 3: Evaluation based on qualitative factors and improved performance

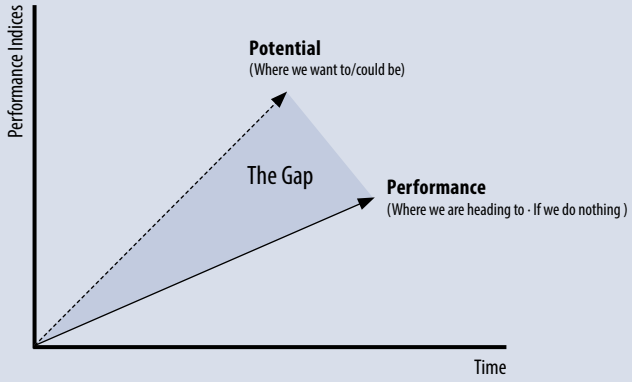
In addition to quantified performance over time, meaningful qualitative factors and improved performance can be specified by description. What is the original status of the factors and how was the performance improved?

The following performance indicators could be considered for selection (but not limited to these factors):

- Quality-related factors: Product performance, delivery reliability, waste, dependability, innovation
- Time-related factors: Lead time, delivery reliability, process throughout time, process time, productivity, cycle time, delivery speed, labor efficiency, resource utilization
- Flexibility-related factors: Manufacturing effectiveness, resource utilization, volume flexibility, new product introduction, computer systems, future growth, product innovation
- Finance-related factors: Cash flow, market share, overhead cost reduction, inventory performance, cost control, sales, profitability, efficiency, product cost reduction
- Customer satisfaction-related factors: Market share, service, image, integration with customers, competitiveness, innovation, delivery reliability
- Human resource-related factors: Employee relationships, employee involvement, workforce, employee skills, learning, labor efficiency, quality of work-life, resource utilization, productivity

FIGURE 1.4

CONCEPTUAL MODEL OF PERFORMANCE GAP ANALYSIS



Step 4: Evaluation based on performance gaps and reflections for continuous improvement

Performance gap analysis aims to investigate why a company isn't performing at its anticipated objectives. The questions to be asked here are "What factors are stopping the company, person, team, product, or process from achieving their maximum capacity, and how can it be fixed?"

Reflections or discussions for continuous improvement can be used to inform managerial implications and decisions or action plans intended to improve or optimize the performance with strategic objectives.

CHAPTER 2

REPUBLIC OF CHINA

INTRODUCTION ON INDUSTRY 4.0 APPLICATION AND CONTEXT CONDITIONS

The term "Industry 4.0", initiated by the German government in 2011, was promoted as an approach to strengthening the competitiveness as well as building the technological leadership of the German manufacturing industry. As the advances in ICT accelerate the implementation of intelligent decision support systems based on data analytics, it has also served as one of the biggest enablers in the current changes in the business models for both manufacturing and service industries. To seek for the opportunity to be early adapters of advanced ICT technologies, a working group of representatives from business, politics, and academia in Germany has been promoting the concept of smart factory. The resulting report of recommendations becomes an integral part of German government's "High-Tech Strategy 2020" initiative to incorporate the trends in higher level of automation and computation in manufacturing processes [1].

The reason behind the Industry 4.0 initiative is due to the low productivity growth in manufacturing. Data from World Bank shows that, despite the more than doubled amount of value added output from manufacturing sectors - USD5.971 million to USD13.143 million - the contribution to GDP has constantly declined, 17.53% to 15.586%, from 1997 to 2017 worldwide [2]. The stagnation in the growth of manufacturing productivity has been a source of great concern and challenge for countries with high manufacturing output, such as Germany, Japan, and Republic of China (ROC). Hence, the advocacy of Industry 4.0 by the German government has inspired other manufacturing-dependent countries to adopt similar initiatives that suit their needs.

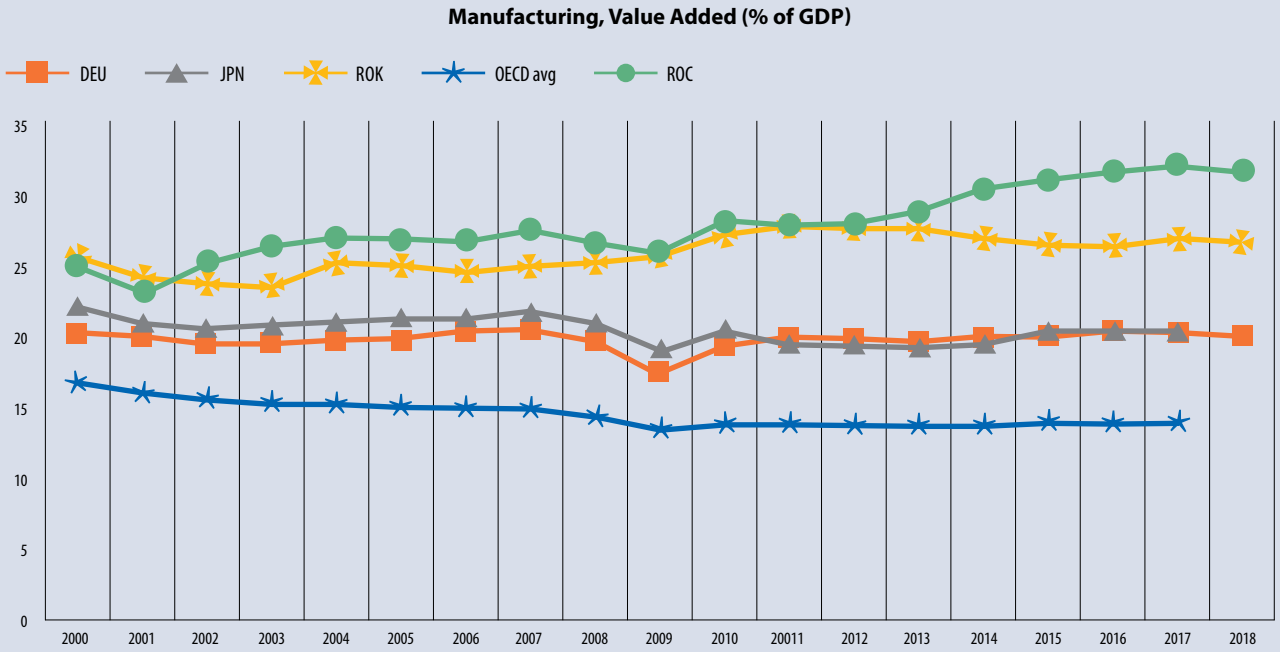
This section highlights a brief introduction with statistics of manufacturing sectors as well as the impact of new technologies on the manufacturing small and medium enterprises (SMEs) in ROC. The following section shows the driving forces behind the dynamism of technological innovation, business model, and market development for Taiwanese corporates. To provide support and create synergy in corporate transformation with Industry 4.0 capability is dedicated to one section, which illustrates successful collaborations between government, academia, and industry. Other enablers, such as designated governmental policies and business environmental infrastructure are also included.

Background of Manufacturing Sector Beginning 2010s

The ROC economy is driven by industrial manufacturing, especially in exports of electronics, machinery, and petrochemicals. Rapid development in manufacturing sectors has been the major force of economic growth during the second half of the twentieth century. With open and globalized trading environment, factories in ROC have become important suppliers and serve as an integral part of the global supply chain. As shown in Figure 2.1, except in 2001, the contribution of manufacturing sectors to ROC's GDP has been more than 25% in the first two decades of the 21st century. While the reliance on manufacturing outputs has remained constant, or even in decline, for developed countries, like Germany, Japan, and other OECD members, the trajectory is upward in ROC. Therefore, it is paramount for the nation to strengthen and elevate its competitive edge in technologies and innovations in the manufacturing sectors as well as to meet the drastic challenges in the global market.

FIGURE 2.1

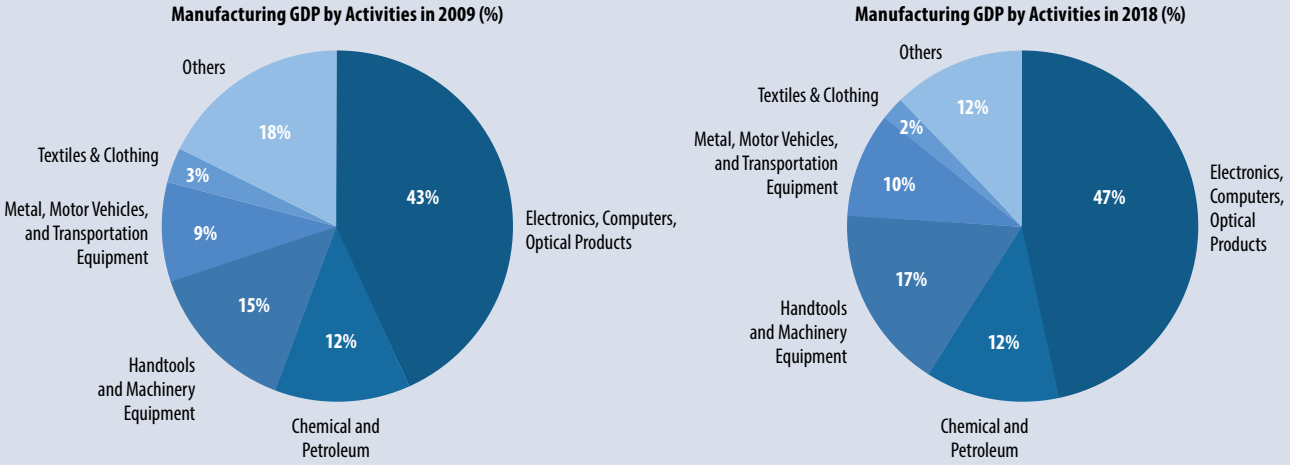
GDP FROM MANUFACTURING SECTORS IN SELECTED COUNTRIES FROM 2000–18



Source: (i) World Bank (available at https://data.worldbank.org/indicator/NV.IND.MANF.ZS?view=chart).
(ii) Directorate-General of Budget, Accounting and Statics, Executive Yuan, ROC. (available at https://www.dgbas.gov.tw/ct.asp?xItem=45002&ctNode=3099&mp=1), both accessed on 10 June 2020.

FIGURE 2.2

ROC GDP IN MANUFACTURING BY ACTIVITIES IN 2009 AND 2018



Source: National Accounts Yearbook (2018). Table 1 GDP by Kind of Activity (at Current Prices), pp. 36–37, available at https://www.dgbas.gov.tw/ct.asp?xItem=45002&ctNode=3099&mp=1, accessed on 10 June 2020.

The heavy dependence on exports exposes ROC's economy to fierce global competition and fluctuations in global demand. When looking into the content of manufacturing exports, almost 64% of ROC's exports was high skill and technology intensive [2]. A 2016 Deloitte report showed that ROC was ranked 7th in the global manufacturing competitiveness, trailing behind Germany, Japan, Republic of Korea (ROK), and the UK, but leading ahead of Mexico and Canada [2]. The statistical analysis of industry and service census in 2016 found that the number of innovation and research in manufacturing sector was higher than in other sector, and the information and electronic industry has the highest ratio in both R&D expenditure and investment in innovation [3]. Other advantages for ROC's manufacturers included highly educated workforce, quality infrastructure, and robust manufacturing clusters [2].

A further breakdown of manufacturing GDP by activities in ROC shows the key activities in this sector in 2009 and in 2018 (see Figure 2.2). The contribution from electronics, computers, and optical products increased by 4%, from 43% in 2009 to 47% in 2018. For the hand tools and machinery equipment industries, the percentage contribution increased by 2%, from 15% in 2009 to 17% in 2018. Similarly, the percentage GDP increased by 1% in the metal, motor vehicle, and transportation equipment industries, from 9% to 10%.

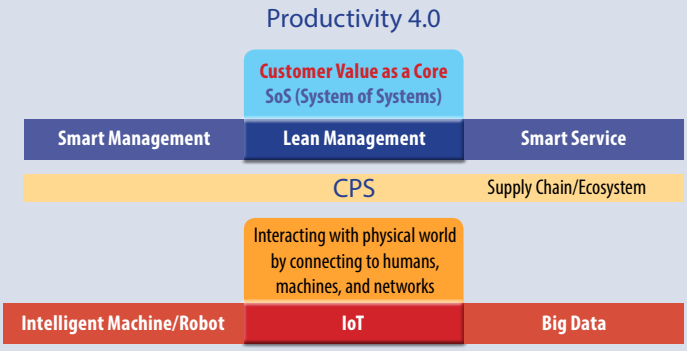
Specific Government-Academic-Industry Collaborations for Industry 4.0 in Manufacturing Sectors

The government of ROC is keen to invest new economic development models in order to keep the island internationally competitive. In 2015, the government proposed the Productivity 4.0 initiative, with a total budget of TWD36 billion over the next nine years [4]. The motivation behind this government initiative was based on the observation of slow growth in labor productivity in 2002 to 2011 in ROC. The number was 3.93%, a 40% to 34% decrease compared with that in 1982 to 1991 and in 1992 to 2001, which was 6.55% and 5.99%, respectively. The expected benefit was to raise the per capita productivity of ROC's manufacturing industries by 60% in 10 years.

The proposed conceptual framework of Productivity 4.0 is illustrated in Figure 2.3. To increase the value output of manufacturing offerings, the project was to push for applications in smart machinery and intelligent production systems to create higher customer value. This initiative includes the Internet of Things (IoT) (machines), big data analysis, and human-machine collaboration to overturn the existing production and service models in both the island's manufacturing and service sectors.

FIGURE 2.3

CONCEPTUAL FRAMEWORK FOR INDUSTRY 4.0 IN ROC [4]



For manufacturing sector, the government's effort was to nudge more companies to become an integral player for the high-end markets. Moving from the traditional paradigm of "mass production", it required these companies to venture forward with advanced product designs, work more closely with target vendors/customers, and move on to the new "small quantity great diversity" and "mass customization" made possible with a flexible and smart technology-enabled production system. One of the benchmarks for this project was to aggregate the latest applications and success cases into industry-oriented Industry 4.0 demonstration sites and to show how companies might adopt, test, and even verify these tools to boost their smart technology competencies following the best practices.

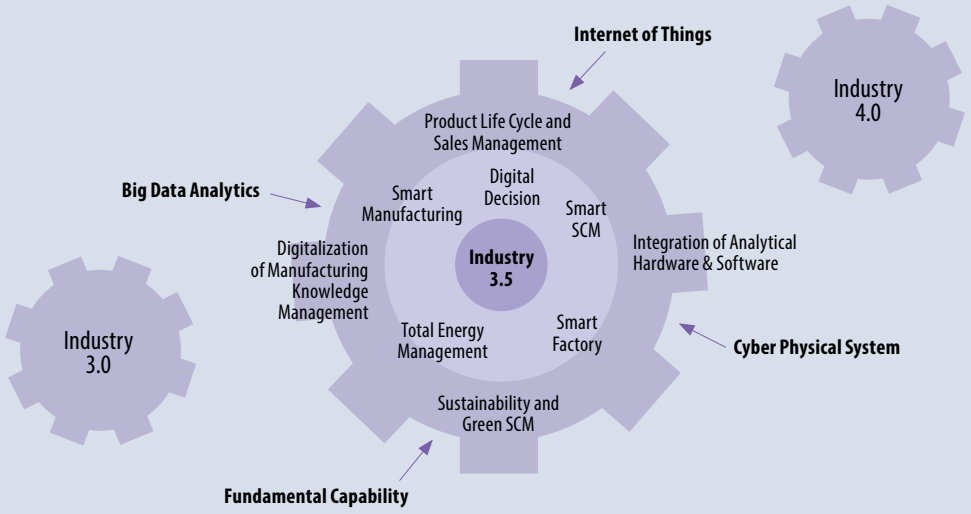
To move up the industry value chain and to identify the best smart technology and automation adoption methods, experts from academia and research institutes were included in most governmental initiatives for experience-sharing and suggestions in production efficiency and value adding. Further, the ROC government also committed to the Center of Excellence on Smart Manufacturing (COE on SM) to provide the leadership in facilitating industry upgrading in the Asia-Pacific region.

As a competitive strategy, Industry 4.0 was proposed to enhance manufacturing capability and flexibility with the advance of artificial intelligence (AI), big data analytics, cyber physical system, and IoT. However, the deployment of Industry 4.0 cannot be achieved overnight, and the production system needs to be ready before the full transformation of Industry 4.0 can take place. Industry 3.5, proposed by Chien et al (2016), might serve as a hybrid strategy between Industry 3.0 and the to-be Industry 4.0 [5]. The strategy in Industry 3.5 includes smart manufacturing, digital decision, smart supply chain management, total energy management, and smart factory, as shown in Figure 2.4.

The purpose of Industry 3.5 is twofold: digitalization and realignment. The first purpose is inward looking. The effort of digitalization is to upgrade management system in production, like manufacturing execution systems (MES) and advanced planning and scheduling systems (APS), as technology advances. It is to build the foundation in knowledge management of the entire manufacturing process with data consistency and standardization. The goal is to achieve the integration of real-time analytical functions, such as preventive maintenance and fault detection and classification, by constantly analyzing data sent directly from sensors using AI-enabled algorithms.

FIGURE 2.4

CONCEPT OF INDUSTRY 3.5 - BRIDGE FROM INDUSTRY 3.0 TO INDUSTRY 4.0



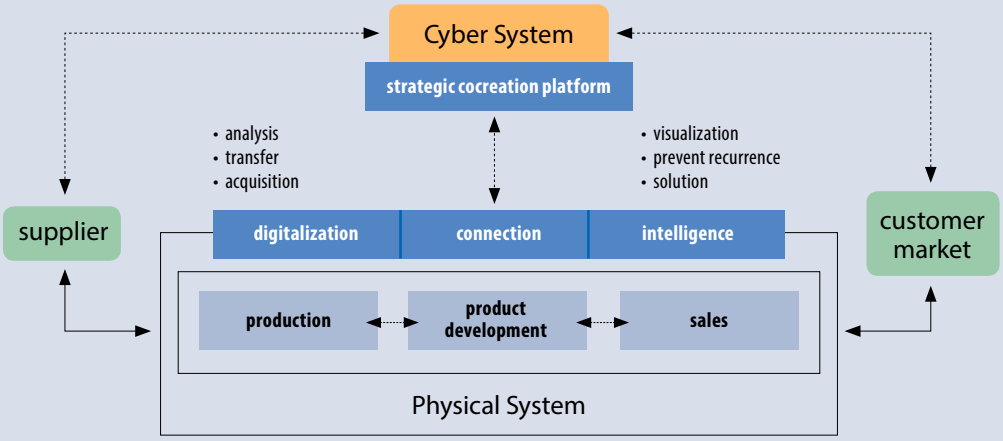
Source: Modified from Chien, Hong, and Guo [5].

The second purpose, realignment, is outward looking. The effort of realignment starts with product life cycle and sales management, which is to have an end-to-end visibility in the capability to meet customer demands. It is to enhance flexible decision-making for ROC corporations to compete in a volatile business environment in the global market. The goal is for ROC companies to find their niche and serve as socially responsible players in the supply chain management, especially with the consideration of environmental sustainability and energy conservation.

Another approach for smart manufacturing transformation is based on lean concept, or referred to as lean smart manufacturing [6]. The platform is shown in Figure 2.5. The first stage in this solution platform is to enhance the physical system with three elements: digitalization, connection, and intelligence. It is then enabled for a company to focus on creating more customer values by strategic cocreation with suppliers and customers using a cyber, problem-solving system.

FIGURE 2.5

LEAN SMART MANUFACTURING ARCHITECTURE AND SOLUTION PLATFORM [6]



With the collaboration effort and resources from government, academics, and industries, ROC's manufacturing sector has reengineered the industry value chain using its strengths in service, digital technology, and integration. The reengineering process revolves around the IoT, machinery capability, and data analytics - three major elements in smart manufacturing. The expected benefits for these adaptable industries are to improve their production efficiency significantly by reducing the total cost of ownership (TCO) and creating more value for customers.

Beneficial Government Policies and Business Environment for Industry 4.0

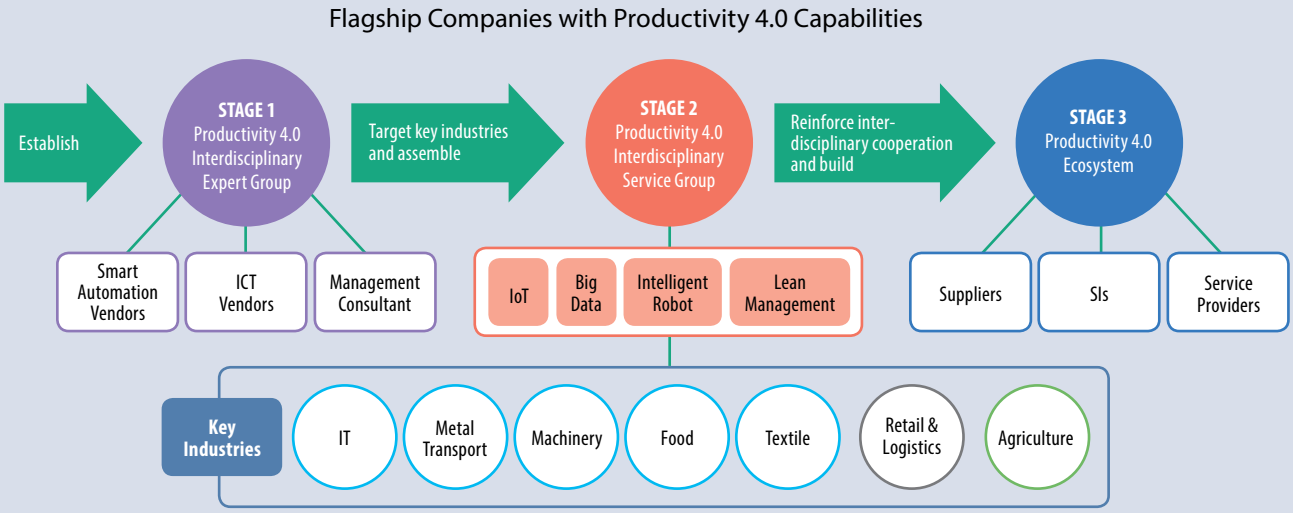
With the aim to promote Productivity 4.0, the ROC government launched several programs to cultivate key core technologies and facilitate transformation to smart manufacturing. As shown in Figure 2.6, there are three stages in ROC's Industry 4.0 policy. In the first stage, it is to establish an interdisciplinary expert panel to provide analysis and suggestions in adopting Productivity 4.0 strategies. Other than experts from research institutes and universities, this group also recruits experienced practitioners from trade associations, vendors of automation, ICT, and general consultants.

In the second stage, multiple focus groups, referred to as the Productivity 4.0 interdisciplinary service groups, are organized for five target key industries; namely IT, metal transportation,

machinery, food, and textile. These service groups would provide assistance for flagship companies to apply government funding and propose applications of IoT, big data analytics, intelligent robots, and lean management regarding the issues and purpose of their transformation plan. It is expected for the flagship companies to serve as leading examples in each industry and motivate other companies, big and small, to duplicate and learn from their transformation experience. Once the Productivity 4.0 system in each industry reaches a maturity level of prototyping and demonstration, the entire concept will then spill over to its suppliers. The ecosystem for Productivity 4.0 can be built with the commercialized services by system integrator (SI) companies and technology service providers in the last stage.

FIGURE 2.6

TRANSFORMATION STAGES AND KEY PARTICIPANTS OF INDUSTRY 4.0 PROJECT IN ROC [4]



The ROC government is also keen to address the needs for SMEs. The statistical analysis of industry and service census in 2016 showed that more than 99.59% of ROC's corporations were SMEs, which hired 64% of available workers and accounted for 41% of GDP in 2016 [3]. With limited capability to invest and innovate, SMEs would assume to be caught in an uphill battle, even many becoming casualties, in the wave of global competition.

To avoid such catastrophe, the semi-official Industrial Technology Research Institute (ITRI) launched the Technical Verification Site for Intelligent Manufacturing in Taichung (http://www.impps.org.tw/) in 2018. The operation of this pilot site's equipment is controlled remotely by MES, which receives and analyzes information relayed by sensors and radio frequency identification (RFID) on the production line. It is used as an open laboratory in which SMEs can test with different options and system designs before implementing on-site based on their specific needs. Within two years, it had helped 30 domestic companies to set up smart production lines.

Similar professional training centers located in northern, central, and southern ROC were opened through inter-agency coordination and combination of industry and academic resources to provide professional training programs and consulting services. Like the initiative of smart manufacturing and services, manufacturing execution system plus (MES+) was proposed by another nonprofit organization, China Productivity Center (CPC), to provide comprehensive guidance for SMEs to plan for digital transformation. The guidance includes system development planning, business management consultation, and professional talent cultivation. MES+ also demonstrates piecemeal solutions for SMEs to realize smart manufacturing with limited investment and changes, such as ways to achieve machine failure prevention by adding smart sensors and analyze the real-time data using AI software.

To encourage SMEs to ramp up their smart manufacturing practices, the Industrial Development Bureau of Ministry of Economic Affairs (MOEA) in 2018 began promoting smart machine box (SMB) projects. Installed on existing machinery, the SMB connects each piece of equipment by way of Microsoft Azure and IoT Edge technology. The Bureau helped 61 SMEs install an SMB on 1,300 pieces of machinery equipment in 2018. That number is expected to rise to the installation of over 9,100 boxes by 2022.

Other beneficial policy includes the Statute for Industrial Innovation which was passed in 2019 to provide tax incentives for those investing in production technology upgrade between 2019 and 2021. Investment that goes directly into smart machinery technologies and 5G mobile communication capabilities qualified for tax deduction, subject to certain conditions. Further, smart machinery technologies are to combine machinery with intelligent technologies, such as big data analytics, AI, IoT, robots, lean management, digitalization management, cyber physical system (CPS), additive manufacturing, and sensing components.

SUCCESSFUL BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

In this section, three cases are introduced to demonstrate successful transformation strategies in ROC's manufacturing sector. The selection of the cases are based on several criteria, including type of industry, size of company, readiness level and position, and adopted strategies for Industry 4.0.

The first selected industry is electronics, computers, and optical products, which contributes almost half of ROC's GDP in the manufacturing sector (see Figure 2.2). The development of ROC's integrated circuit (IC) industry is a unique model with successful execution processes due to the government's strategic technology transfer policy [7]. By delegating the function of R&D of IC technology to the government-sponsored research organization, ITRI, it allowed private companies to commercialize IC technology efficiently and effectively from the 1970s onwards.

One of the cases shared in this section is Taiwan Semiconductor Manufacturing Co. (TSMC), which has the second largest wafer capacity in the world. In 2019, ROC's IC wafer capacity reached to a global share of 21.8%, ahead of 21.3% for ROK, 16.8% for Japan, and 12.8% for North America. Out of the entire IC industry, wafer manufacturing has been critical and is also one of the most pronounced in ROC.

The second selected industry is the automotive component industry - metal, motor vehicle, and transportation equipment. It collectively contributes 10% to ROC's GDP in the manufacturing sector (see Figure 2.2). Moreover, the motor vehicles and automotive parts manufacturing accounts for 2.4% of ROC's GDP in the manufacturing sector in 2018, and is highly decentralized. According to the company registration data in April 2020, a total of 2,513 companies were registered in this category and more than 90% of the companies' capitals were less than TWD30 million. Only 19 of them were with capital of TWD500 million and more [8]. One of the cases shared in this section is H Company, which is among one of the largest ROC vendors in automotive connectors. It also serves the car market in China and the motorcycle market in Vietnam and Indonesia.

Handtools and machinery equipment is the third selected industry that contributes 15%–17% of ROC's GDP in the manufacturing sector (see Figure 2.2). The machinery industry in ROC is competitive in the global market and is the sixth largest exporter of rubber/plastic machinery and textile machines. According to the Taiwan Association of Machinery Industry (TAMI), there are about 230,000 employees working in the ROC 's machinery industry in 2018, which is made up of 13,300 companies. Most of these companies are SMEs, and only a few of the larger ones were willing to raise funds from stock market. Hence, it is astonishing to see ROC's machinery tool industry competing with the world's top machine tool makers who are also global industry giants.

ROC is the world's 4th largest exporter of machinery tools and components, and there are more than 1,000 precision machinery manufacturers and more than 10,000 upstream suppliers. One of the cases shared in this section is Yinsh Precision Industrial Co., which is a general component supplier. With a humble start as a family owned, small company that served the domestic market, its transformation into a global supplier and become the third largest precision lock nuts provider is an exceptional SME survival story.

Case Study 1: Semiconductor Manufacturing - TSMC

Founded in 1987, Taiwan Semiconductor Manufacturing Company (TSMC) is an independent semiconductor manufacturing foundry and provides services for advanced ICs manufacturing for all kinds of consumer electronics. In 2018, TSMC's facilities included four 12-inch fabs, four 8-inch fabs, and one 6-inch fab in ROC; one 12-inch fab in Nanjing, China; one 8-inch fab in Shanghai, China; and one 8-inch fab in Washington, USA. Headquartered in Hsinchu, ROC with around 50,000 employees, TSMC is the first foundry to provide 5-nanometer production capabilities, which is the most advanced semiconductor process technology available in the world.

The semiconductor manufacturing process is illustrated as follows. After silicon wafers are polished, the wafer fabrication is an iterative process of material deposition, lithography, etching, and other steps. The set of process can be repeated 30 to 40 times to build a three dimensional structure. Then, the completed wafer is sent to semiconductor assembly and test services, like Advanced Semiconductor Engineering (ASE), to separate the wafers into individual dies before chips packaging and testing [9].

Compared to other IC manufacturers, like Intel or Samsung, TSMC is unique as a pure IC foundry. The challenges come in balancing needs from ever-changing customers' design and the

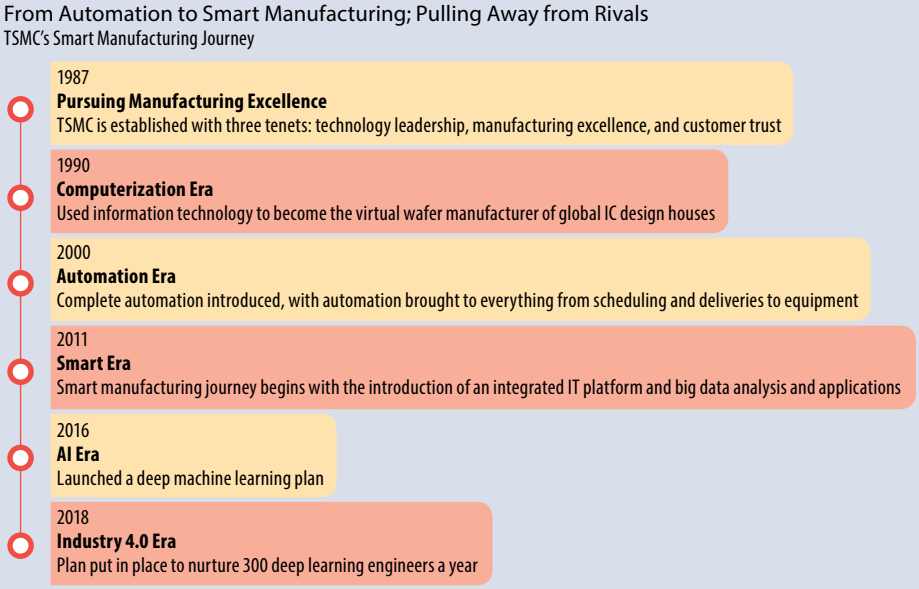
utilization of expensive capacity. The uncertainty of demands forces TSMC to constantly push its limits in diversifying its customer base. On the same token, TSMC needs to keep investing in advancing technologies to handle a diversified product portfolio. For example, TSMC reached an agreement to collaborate with Intel and Samsung in developing 450mm wafers to drive down the cost structure.

Due to the capital-intensive nature of semiconductor manufacturing, it is critical to maximize the utilization of the manufacturing tools and avoid errors that may result in loss of capacity. The set of instructions, referred to as recipe, details the steps to convert the bare silicon through hundreds of operations on different tools into a final product. A typical recipe includes approximately 300+ steps, and a wafer could use the same type of tool as many as 30–40 times in a recipe to build layers on the wafer. The cycle time for wafer fabrication is highly dependent on the number of layers and the lithography technology used, and could range from 90 hours to more than 300 hours.

TSMC keeps improving its operational capability in process control to meet the strict specifications and requirements in quality, reliability, and performance in order delivery. As advanced technology continues to evolve and the geometry keeps shrinking, the need for tighter process control and quality requirement becomes extremely challenging for manufacturing. The timeline for TSMC's strategy in computerization, automation, and then intelligent toward Industry 4.0 is in Figure 2.7 [10].

FIGURE 2.7

TIMELINE OF SMART MANUFACTURING TOWARD INDUSTRY 4.0 IN TSMC [10]



The automation era began in 2000 when TSMC built a massive 12-inch wafer fab whose degree of automation surpassed that of any of its rivals' facilities. To boost effectiveness of manufacturing equipment and reduced cycle time, TSMC wished to develop systems for precise fault detection

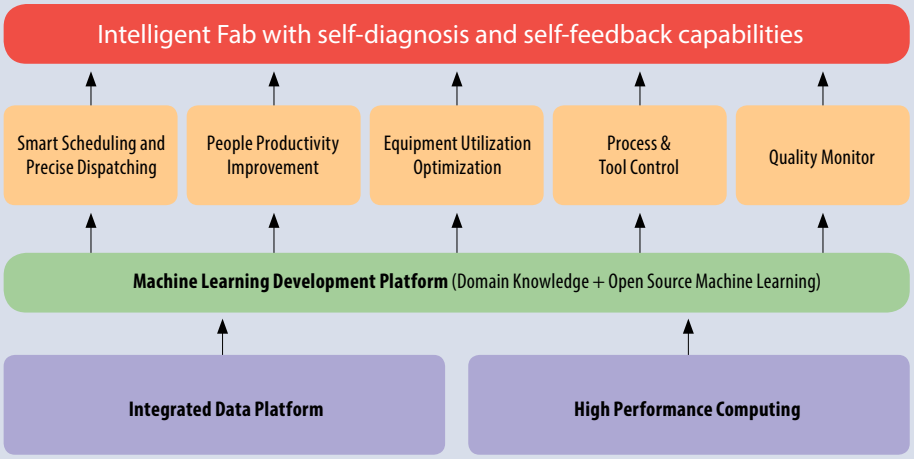
and classification. With intelligent advanced equipment control and intelligent advanced process control, TSMC can monitor the manufacturing process in a timely manner and adjust conditions precisely to meet the demands. It is also impressive that fewer than 1,000 process engineers were responsible for foundries in ROC, as every foundry had thousands of pieces of equipment.

After a decade of automated data collection, TSMC started the smart era in 2011 to put these data into analysis. The amount of data accumulated was magnificent. Every TSMC wafer would generate a million points of data. Instead of using standard commercial statistics software that supports big data analysis, TSMC decided to develop its own analytical tools consistent with its own specific requirements. Part of the key analytical technologies and processes were patented to protect its specialized feature and business edge.

In 2016, TSMC recruited around 1,000 IT and machine-learning engineers and launched a deep machine-learning plan. In 2018, TSMC recruited 300 AI specialists to join the effort. They were expected to develop smart diagnosis engine and advanced analytics platforms over the past few years that have supported the creation of a unique manufacturing precision control system. To achieve excellence in both quality and manufacturing, TSMC's process control systems have been integrated with numerous intelligent functions to assist auto-diagnosis, self-learning and self-reacting. These, in turn, have demonstrated remarkable results in yield enhancement, quality assurance, workflow improvement, fault detection, cost reduction and shortening of the R&D cycle. The structure of intelligent fab system in TSMC is shown in Figure 2.8.

FIGURE 2.8

SYSTEM STRUCTURE OF AGILE AND INTELLIGENT OPERATIONS IN TSMC



Source: www.tsmc.com.

Case Study 2: Automotive Component Manufacturing - H Company

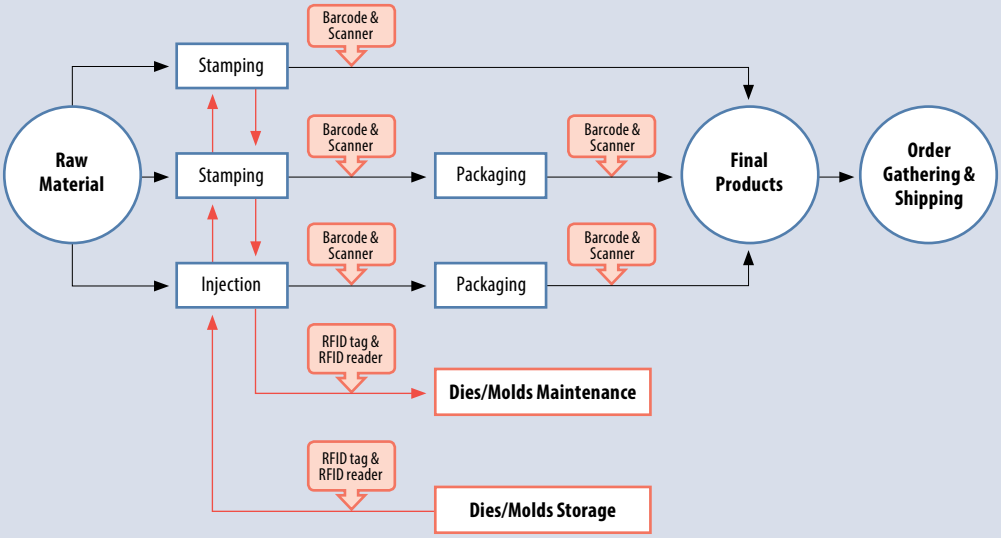
Founded in 1977, H Company has been serving as a professional vendor for motor vehicle connectors since 1989. With around 2,000 employees, H Company is a second-tier supplier for

car manufacturers and has four manufacturing facilities: Taipei (ROC), Dongguan (China), Nanjing (China), and Vietnam. From the company's corporate social responsibility report in 2018, more than 89% of its total sales were in the Asian market, including 10% from ROC, 67% from China, and the rest in Southeast Asia. The automotive connectors market that H Company serves includes comfort, convenience, and entertainment (CCE), powertrain, safety and security, body wiring and power distribution, and navigation and instrumentation.

There are four basic parts in an automotive connector component: contact parts, housing, insulator, and accessories. The production process requires two types of equipment: stamping machines for metal contact parts, and plastic injection machines for housing and insulator. The number of connectors required to assemble for one car has increased significantly, from around 100 to more than 600. Advancements in technology have introduced many new features in vehicle designs, and any enhancement in vehicle features significantly increases the use of electronic components. For example, new safety and security features, such as adaptive cruise control, adaptive front lighting, lane departure warning, and park assistance require a high number of sensors, electronic components, and engine control units (ECUs). It requires various types of connectors to establish reliable connectivity between these components [11].

FIGURE 2.9

PRODUCTION INFORMATION CONTROL SYSTEM IN H COMPANY



The production flow in H Company is illustrated in Figure 2.9. The stamping process produces connector terminals, or the contact parts, with high volume stamping machines. The injection molding process produces housing with materials of elastomer, thermoplastic, and thermosetting polymers. Both processes are automated with robotic loading and unloading, and equipped with on-line automated optical inspection (AOI) for quality assurance [11]. As the quality of products and efficiency of connector manufacturing processes relies heavily on the design of dies, H Company has also made aggressive R&D investment in molding technology. H Company has accumulated 142 patents in molding processes and die designs, and more than

half of them are for plastic injection modeling, as disclosed in the company's corporate social responsibility report in 2018.

Since 2010, H Company started to develop a real-time production control system to monitor more than 300 machines in the facility. A barcode system was connected to the enterprise resource planning (ERP) system for the information of orders and production lots. Then, operators in the production lines collect production data by scanning barcodes to link production lots with machines. A web-based MES that visualizes production data allows managers to check out capacity utilization and order status anytime, anywhere. Similar system was adopted for stamping dies and injection molds. Using RFID tags and readers, the location of individual die/mold can be easily tracked and any misplacement would be notified in real time.

Case Study 3: Machinery Component Manufacturing - Yinsh Precision Industrial Co.

Yinsh Precision Industrial Co., founded in 1989 by Guo-Hua Lin, is a family-based processing plant that produces precision lock nuts in Taichung, ROC. In 1999, You-Chong Wu was named the president of the company. Since You-Chong Wu is Lin's son-in-law, Yinsh remains a wholly-family owned company. With about 180 employees, Yinsh is the third largest precision lock nuts provider in the world. Though its customers are located internationally, all Yinsh's R&D and production facilities are located in Taichung, ROC.

The lock nuts manufactured by Yinsh ranges from standard to customized balanced lock nuts and grinding lock nuts, which comes in various designs and shapes. Currently, Yinsh produces around 350,000 lock nuts per month that makes 80% of all industrial lock nuts in ROC and supplies to more than 3,000 domestic customers. Yinsh also exports lock nuts to more than 30 countries globally, with Mazak and DMG forming as part of its clientele.

A nut is a type of fastener with a threaded hole. Nuts are usually used in conjunction with a mating bolt to fasten multiple parts together. The two partners are kept together by a combination of their threads' friction, a slight stretching of the bolt, and compression of the parts to be held together. Lock nuts are used to locate bearings onto a shaft and form one of the critical components in machine tools, where each unit uses more than 10 lock nuts to hold the bearings in place. The competition factors include distribution partnerships, technological innovations, product portfolio, strategic developments, and capabilities.

Industrial lock nuts are nuts that resist loosening under vibration and torque. This makes them useful for holding wheels onto axles, or in automotive engines where machine vibration would otherwise loosen the fastener. Fasteners used in automotive, engineering, and industrial applications usually need to be tightened to a specific torque setting, using a torque wrench. High-quality fasteners are required for manufacturers in automotive and aerospace sectors and these products are subject to rigorous quality standards, such as ASTM, ASME, BS, DIN, and JIS. More than 140 ROC companies have gained aerospace certification to manufacture aerospace fasteners within the strict quality control and certification standards, such as AS 9100 and NADCAP.

In the late 1990s, the company was sunk deep in debts due to fierce competition and diminished profitability in standard lock nut market in ROC. To avoid bankruptcy, Guo-Hua Lin then handed the company to the twin brothers, You-Chong Wu and You-Jie Wu, who were named as the

president and vice president, respectively. Dominated by makers in Japan and Germany, the market for key components, such as spindles, ball screws, and lock nuts for multiaxis, advanced machines were almost nonexistent for ROC manufacturers. However, instead of serving as a vendor to larger lock nut companies, You-Jie Wu aimed to establish Yinsh as a brand name and sell directly to the largest machinery manufacturers globally.

To become an order qualifier, You-Chong Wu was leading a total transformation in Yinsh to meet customer demands with the highest standard in technology and product quality. Wu initiated several projects to improve quality. For example, introducing automatic 3D inspection machines in the manufacturing floor for quality assurance, replacing general-purpose machines by numerical control ones, and recruiting and training workers by closely working with local community colleges. With strong dedication and the help of the academic-industry collaboration, Yinsh was able to transform from a small workshop of around 20 full-time employees into a medium-sized company, with eight production sites and more than 150 workers, who are mostly college-educated.

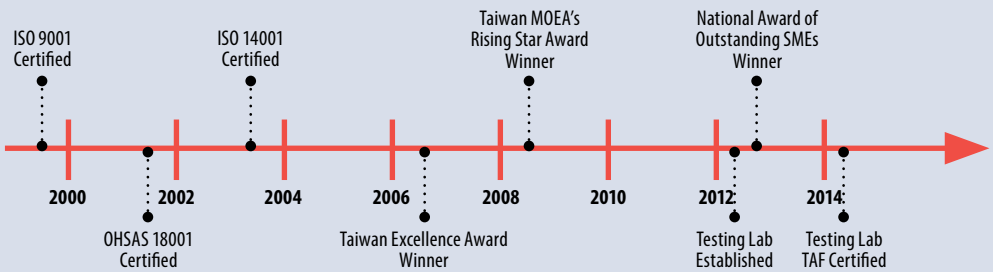
To earn customers' trust in quality and production capability, Yinsh was aggressive in gaining world standard certifications, such as ISO 9001 in 1999, OHSAS 18001 in 2001, and ISO 14001 in 2003. Yinsh had applied and won several national-level awards as a way to motivate employees when pursuing for excellence, such as the Taiwan Excellence Award in 2006 for product excellence. In 2008, Taiwan MOEA honored Yinsh as one of the 11 winners for the 11th Rising Star Award for SMEs which had excellent export performance and were highly competitive, both operationally and managerially.

To become the order winner, Yinsh had set up a precision QC lab in 2012, which was accredited by Taiwan Accreditation Foundation (TAF) in 2014, to demonstrate its capability in meeting the world-class standard in product quality. In the same year, Yinsh won the 21st National Award of Outstanding SMEs by Taiwan MOEA, which recognizes outstanding SMEs and serve as paradigms for SMEs in sustaining their competitiveness. Figure 2.10 shows the milestones for Yinsh Precision Industry Co in the early 2000s and 2010s.

With the reliable operational capability and product quality, Yinsh then shifted its focus on capacity utilization and order management. In 2015, You-Chong Wu started a 10-year initiative in Yinsh's transformation into smart manufacturing with the following four objectives:

FIGURE 2.10

TIMELINE OF ACHIEVEMENT FOR YINSH PRECISION INDUSTRY CO.



Source: www.yinsh.com.

- **Automation:** To reduce production costs and increase workplace safety by utilizing robot-assisted manufacturing processes and automated machining parameter settings

- **Flexibility:** To upgrade single machinery into machining center to increase the capability for high-mix, low-volume with smart production routings

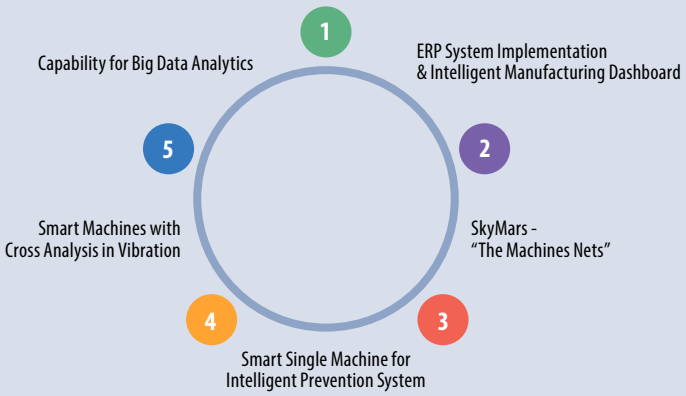
- **Intelligence:** To allocate resources smartly that fits market needs by the adoption of AI, IoT, and big data analytics on data-related process and order management

- **Energy conservation:** To reduce the impact on environment by eliminating any contamination during the production process and by saving energy with certified, energy-efficient machines

With the support by the Precision Machinery Research & Development Center (PMC), which is a nonprofit organization partly owned by the government, a panel of experts was organized to assist Yinsh in its digitalization process. The panel proposed a five-stage roadmap (see Figure 2.11) for Yinsh to transform into smart manufacturing.

FIGURE 2.11

ROADMAP FOR YINSH'S SMART MANUFACTURING TRANSFORMATION



Source: www.yinsh.com.

The first two stages - the implementation of ERP system and SkyMars system, which collects real-time production data and connects all CNC machines within a facility, were critical for Yinsh to transform from Industry 3.0 to Industry 3.5. Partially funded by government projects, a local solution provider was involved to develop the ERP system for Yinsh for its specific needs in 2016.

The SkyMars system was also partly assisted by a government-sponsored proposal, referred to as smart machine box (SMB), which provided technology support, such as Wi-Fi and IoT to connect machines in 2017 and 2018. Most commercially available solutions that can fully connect machines were too expensive for most SMEs, let alone the consistency issues in the infrastructure requirement and the additional costs needed to maintain the system. With a team of experts from the IT industry, academics, and research institutes, the goal of this SMB

project is to assist SMEs to have a quick and easy option to collect and digitalize production data that is just right for the SMEs, according to their needs.

One quick win for this SkyMars system was the capability to visualize real-time production data in any location so that managers can quickly respond to urgent events or to better utilize manufacturing resources even if they are not in the shop floor. By the end of 2018, Yinsh was able to digitalize all of its 150+ machines across six different locations. The benefits include 13.6% increase in productivity, 20% increase in machine utilization, and 7% increase in product yield.

In 2019, the MOEA approved a TWD100 million project for Yinsh to continue its transformation, which was part of a total TWD2.8 billion (USD91.69 million) investment plan to assist ROC's SMEs to update and upgrade their capability. The goal of this project was to set up two smart production lines to cut its labor costs in Yinsh. It is to assist Yinsh to further its transformation from Industry 3.5 to Industry 4.0 by integrating the SkyMars with MES and ERP systems and to extent their capability with technology of AI and other smart technologies. Ultimately, it is expected to have a total makeover for Yinsh to transform decentralized facilities with stand-alone machines into a centralized, fully connected, and remote accessible manufacturing environment with intelligent-embedded information systems within the next five years.

DATA AVAILABILITY

Primary Data

In order to find successful cases in manufacturing transformation for Industry 4.0, the primary data collected are from interviews. The first search was on the industry level. To narrow down the types of industry in ROC's manufacturing sector that could be exemplary in Industry 4.0, four telephonic interviews were carried out. These included interviews with Karen Hsueh, the deputy manager of the APO Affairs Department, the Office of the APO director for ROC, Fu-Lin Chen, the manager of the Office of Industrial and Academic Cooperation (OAIC) in Taipei Tech, and Dr. Kai-Ying Chen, the assistant dean of College of Management and professor of Department of Industrial Engineering and Management in Taipei Tech.

Once a candidate company has been identified, public data, like news article and journal articles, were searched and summarized for the case company. The draft was then used in two follow-up interviews in person. Both were semi-structure interviews. The first interviewee was Dr. Kai-Ying Chen on the production strategies in H Company, which went on for about 30 minutes. Another interview was conducted in Taichung for more than two hours, including a visit to the manufacturing floor. The interviewee, David Liu, PhD, is the Vice Convener of the Intelligent Manufacturing Promoting Alliance in Yinsh Precision Industry Co. Ltd.

Secondary Data

Most of the secondary data collected in this report are from administrative data and government censuses by National Statistics, ROC. For public companies, financial data were collected from goodinfo.tw, a search portal for companies listed on ROC's stock market. Other cited information are included in the reference.

ANALYSIS OF CASE STUDIES

In this section, for each case, a brief analysis of the associated business strategies for its manufacturing transformation status and purpose are introduced. The structure includes an evaluation of the case company, strategy planning, and key performance indicators.

Analysis of Case Study 1: Semiconductor Manufacturing - TSMC

Taiwan Semiconductor Manufacturing Company (TSMC) has been unique in its business model as a service company that had to respond to various specs and needs of its global customers. As the largest chip contract manufacturer in the world, TSMC "places an extremely high value on disciplined execution to improve first silicon success for its customers, and give it the flexibility to respond quickly to changing demand signals from those customers giving them agility in volume-to-market [12]".

A. Economic Alignment

As observed by Gordon Moore, semiconductor devices have been getting more complicated as the number of transistors have doubled every two year since 1975, and referred to as the Moore's law. It also sets the target for manufacturers to invest heavily in R&D to advance technology as well as manufacturing capability. Once the advanced technology matured, the production cost can then be dramatically reduced as the yield improves. On the same token, it would then be utilized in consumer electronics products since more function can be combined into a single chip and increase revenue for the manufacturers. Therefore, technology innovation and advances in manufacturing capacity were the critical factors for the success in semiconductor industry in this cycle [13].

To keep up with the latest technological innovation, it relies on a healthy revenue growth to sustain the investment in R&D. TSMC has been solid financially. The annual gross profit has constantly increased, from around TWD21.1 trillion in 1997 to TWD492.7 trillion in 2019. At the same time, the R&D expense has also increased, along with the growing revenue. The percentage of net revenue allocated to R&D has been more than 7% since 2009. The ratio reached the highest level of 8.54% in 2019. By pushing the latest 5-nanometer production capabilities, TSMC is in the leading position in defining market trends.

B. Technology Utilization

One of the business plans for TSMC is to "substantially ramp up the business and sustain advanced technology market share by continued increasing capacity and R&D investments." To remain cost effective, high yield is key. For semiconductor companies to develop their strategy in the pursuit of excellence in their operation systems, Harvey Wohlwend [14] has developed an e-Diagnostic system for the semiconductor industry. It is to integrate three capabilities in semiconductor manufacturing processes: equipment engineering capability (EEC), MES, and equipment integration, and automated material handling system (AMHS). The overall e-manufacturing system allows remote access and collaboration, data collection and control, problem analysis and predication within an integrated platform, and is embedded into the internal enterprise network.

The core technologies involve in perfecting this control system are IoT, big data analytics, and AI. To develop smart diagnosis and advanced analytics capability, TSMC has recruited machine-learning engineers as well as AI specialists since 2016. It is to create a unique manufacturing precision control system to better meet customer needs.

C. Talent Development

TSMC headquarters in Hsinchu, ROC is advantageous in recruiting talents. It is close to ITRI, which is the technology R&D institute that transferred IC manufacturing processes to ROC in the 80s. It can also tap into two universities, National Tsing Hua University and National Chiao Tung University, for top-notch talents in science and engineering. The training and recruitment effort starts before potential employees leave campus.

In 2016, TSMC recruited about 1,000 IT and machine-learning engineers, and launched a deep machine-learning plan. In 2018, TSMC recruited 300 AI specialists to join the effort. They were expected to develop smart diagnosis engine and advanced analytics platforms over the past few years that have supported the creation of a unique manufacturing precision control system.

D. Supply Chain Collaboration and Partnership

TSMC has used various procurement strategies in managing various suppliers in quality assurance, delivery, and even green and sustainability policy to prevent potential supply chain risks. For example, raw material worldwide suppliers, such as BASF, DuPont, and Merck, have relocated part of their capacity closer to TSMC's wafer fabs to improve the procurement logistics and reduce supply risks. For lithographic materials, TSMC works closely with vendors to develop materials that meet specifications and cost requirements.

E. Market Competitiveness

The business plan for TSMC is to "continue to enhance the competitive advantages of the company's platforms in smartphone, high performance computing, IoT, and automotive electronics design ecosystems so as to expand TSMC's dedicated foundry services in these product applications."

TSMC has been constantly expanding its capacity since 1997. In 1998, it operated two 6-inch wafer fabrication facilities (Fab I & II) and three 8-inch ones (Fab III, IV and V). In 2019, the annual capacity of the manufacturing facilities managed by TSMC and its subsidiaries exceeded 12 million 12-inch equivalent wafers, which accounts for 67% of ROC's IC capacity. The average growth in wafer fabrication ("fab") capacity is about 800,000 of 12-inch equivalent wafers per year.

At the same time, to be able to increase revenue, it is critical to maintain a high capacity utilization. The capacity utilization remained to be above 80% in TSMC except in 1998, 2001, and 2009. When the demands went up, the capacity utilization was even higher than 100% in 2004, 2006, 2010, and 2014.

F. Innovation Ecosystem

While TSMC worked to perfect its yield management, equipment utilization, smart planning and scheduling, and precise dispatching, the company gradually moved into the semiconductor devices and components after 2014. Based on a patent analysis done by Chen at el. (2018), they found that the International Patent Classification (IPC) of TSMC's patents submitted before 2014 were mainly to the category of a method or equipment for manufacturing semiconductor or solid device or components. "After 2014, H01L002978, and H01L002966 became TSMC's main IPCs, which cover semiconductor devices for rectification, amplification, oscillation, and switching. This information shows that TSMC's technique is increasingly including semiconductor devices and components instead of the process of making semiconductors" [15].

G. Strategic Management

Based on the annual report of TSMC in 2019 [16], the strategy for TSMC to remain competitive as "the focus of customer demand is shifting from process-technology-centric to product-application-centric" is its "differentiating strength". They are constructing application-oriented platforms to shorten customers' time-to-design and time-to-market; namely, for smartphone, high performance computing, IoT, and automotive electronics.

H. Regulation of Operations

Based on the annual report [16], TSMC has established a compliance program to implement regulation requirements and ethical policies with year-round compliance awareness training sections. The practical experiences are shared with their suppliers on topics in ethics, labor rights, occupational safety, and environmental protection via annual Responsible Supply Chain Forums [16].

The strategy map for TSMC in adopting Industry 4.0 technologies is illustrated in Figure 2.12. For financial perspective, the objectives are to keep constant sales growth, to sustain high capacity utilization, and to diversify customer base and sales channels along with the market trends. It requires to serve the customers by achieving shorter time to market, better obtainability of products, and higher first silicon success to cope with shorter life cycle of consumer electronics. The objectives for internal process perspective are to extend internal business processes with the focus on market intelligence, process and operations optimization, and technological innovation. In terms of learning and growth perspective, it requires the creation of internal AI and IT suite, the cultivation of cross-fab training culture, and the pursuit of green energy for sustainability.

The dynamics in related quantitative measures - cycle time per layer (days), and wafer yield (%) - for TSMC toward its Industry 4.0 era are shown in Figure 2.13. Both measures are directly related to the two "weapons" that TSMC focuses on to widen its distance from its global competitors in its smart manufacturing strategy [10].

FIGURE 2.12

STRATEGY MAP FOR TSMC

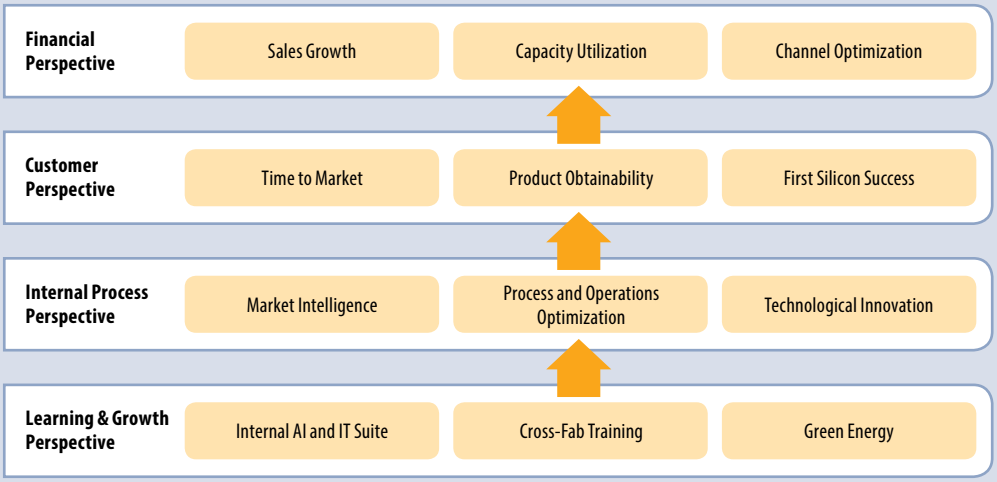
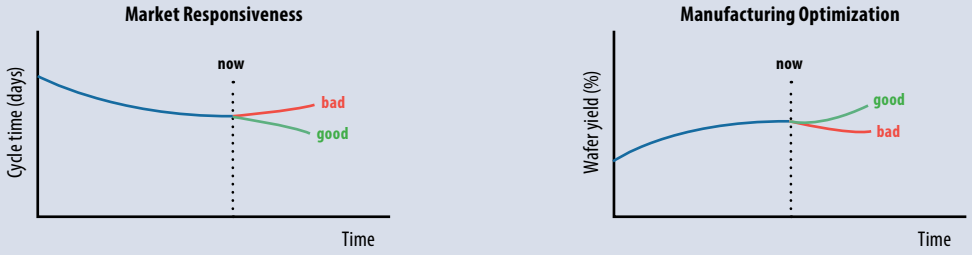


FIGURE 2.13

STRATEGY DYNAMICS IN MARKET RESPONSIVENESS AND MANUFACTURING OPTIMIZATION OVER TIME FOR TSMC



The first focus is the capability to reduce the cycle time by continuous improvement in operation efficiency. The semiconductor manufacturing process requires repetitive iterations in material deposition, photoresist coating, exposure, developing and baking, etching and ion implantation, and ashing processes to build layers. The cycle time refers to the time it takes to build each layer, and usually takes 1.3 to 1.6 days for a fab to process a layer [17]. It requires 30 to 40 cycles to build a 3D structure, which equals to an order lead-time of at least 39 to 64 days. Therefore, the ability to improve cycle time has become a key competitive aspect in the semiconductor industry. In TSMC, "the company's cycle time has improved by at least 50% since it began adopting smart manufacturing practices and applying big data and machine learning" [10].

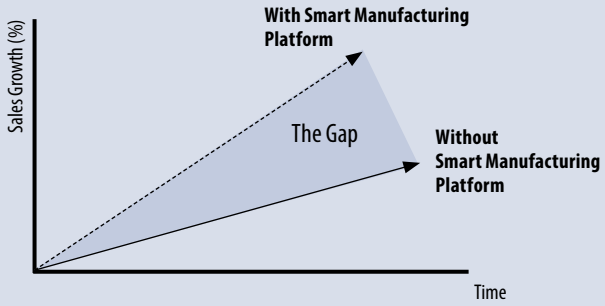
The second focus is on optimizing precision manufacturing. TSMC has constantly expanded its capacity with 13 fabs worldwide. TSMC "generally has its main foundry conduct the necessary tests until the process is considered stable before the chip can be turned over to one of the fabs

for mass production" [10]. However, instead of replicating exactly the process conducted in the main foundry, TSMC's fab-matching model adopts a two-way learning. That means, "if a production process in one fab generates better process parameters or higher yields or drives the use of a more cost-efficient machine, other fabs will realign themselves with the new findings" [10].

After a decade of automated data collection, TSMC has developed its own analytical tools consistent with its own specific requirements. Key analytical technologies, such as machine deep learning and artificial intelligence are fully utilized to protect its business competitive edge. It allows TSMC to improve its productivity by smart scheduling and precise dispatching, quality monitoring, process and tool control, and equipment utilization optimization. With this platform in smart manufacturing, the potential improvement in its sales growth for TSMC is shown in Figure 2.14.

FIGURE 2.14

PERFORMANCE GAP IN SALES GROWTH FOR TSMC



Analysis of Case Study 2: Automotive Component Manufacturing - H Company

H Company sets up its manufacturing facilities close to the market it serves - China, Vietnam, and Indonesia. All facilities in H Company are certified with the latest version of IATF standard for compliance to quality and process standards. The top five customers for H Company in China include Geely Auto, Chang'an Auto, BYD Auto, Great Wall Motor, and SAIC-GM-Wuling Auto. With the threat of new comers in electronic vehicles and limited mobility due to coronavirus, the car industry is under huge stress to be more agile and innovative to remain competitive in the market.

A. Economic Alignment

The financial performance for H Company is highly correlated with the growth of car market in China and Southeast Asia. The annual gross profit has constantly increased sixfold from 2001 to 2019. During the same period, the percentage of net revenue allocated to R&D was raised from 1.35% to 4.89%. It is aligned with the market trends in multifunctional, electronic-oriented connectors for vehicle designs with shorter life cycle.

B. Technology Utilization

Advancements in technology have introduced enhanced safety and security features in vehicle designs with the use of electronic components. New features, such as adaptive cruise control, adaptive front lighting, lane departure warning, and park assistance require a high number of sensors, electronic components, and ECUs. It requires various types of connectors to establish reliable connectivity between these components. As a result, the number of connectors required for one car has increased from about 100 to more than 600.

To meet the changing customer requirements and remain profitable, the core technologies involved are IoT and big data analytics that could improve the management capability in various activities, such as sales inquiries and production matches.

C. Talent Development

With fully automated production lines, H Company is able to tap into low cost labors with minimum skill required, especially in developing markets. Its human resource strategy is to allow line managers and talented juniors to work on problem-solving oriented projects with vocational schools. It also reaches out to local communities and provides internship to college students in their senior year.

D. Supply Chain Collaboration and Partnership

Car industry has a long product life cycle and its production process requires a total compliance in safety regulations for the global markets. Given the nature of its products, the automotive industry has a deep and complex global supply chain. Inspired by Toyota manufacturing practices, the car industry prefers a stable supply chain structure with long-term relationship of close-knit vendors and dealers.

E. Market Competitiveness

The existing supply chain of the automotive industry has rigid hierarchy between tiers of suppliers. Even though the competition within each tier seems to be limited, any supplier in that tier needs to keep improving its productivity to be appealing to potential customers downstream. One way to demonstrate and convince customers is to achieve transparency in production data. It also helps in communicating with its customers in tier one in terms of deliverability and efficiency.

F. Innovation Ecosystem

H Company is a second-tier supplier for car manufacturers. As car companies are shortening their lead-time in product development, H Company is also adjusting its strategic resource allocation toward R&D to enhance its capability in mold and die designs that are critical to produce specific connectors for electronic control units more effectively.

G. Strategic Management

As a typical player in the car supply chain, lean concept and continuous improvement has been the holy grail in strategy planning. It is straightforward for H Company to seek for lean smart manufacturing strategy (see Figure 2.5). Following the concept of lean smart manufacturing, H Company has been in the first stage of creating customer values by fine-tuning its physical system with improvement in quality and resource utilization, including machines, capacity, and inventory turnover rates. To link customer values with product-related activities, H Company is also developing and collecting strategic quantitative measures for value management.

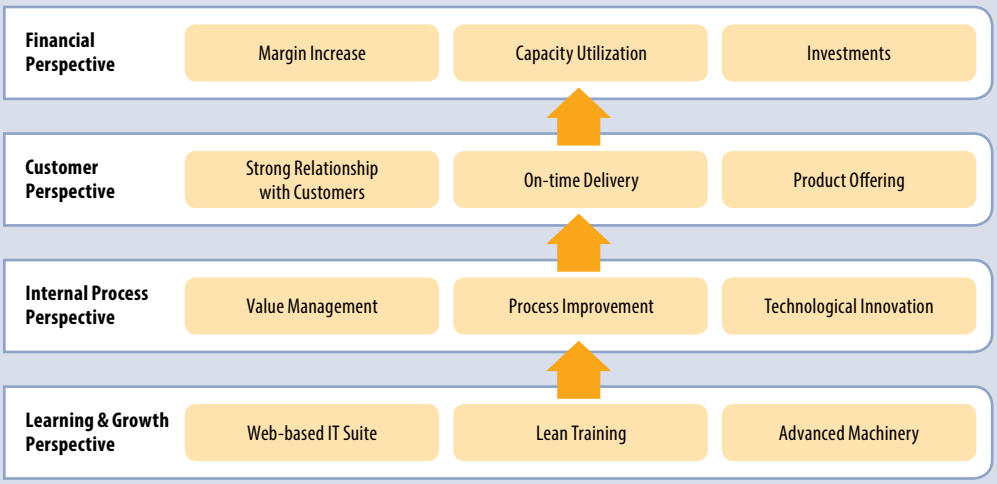
H. Regulation of Operations

Automobile is one of the most regulated products in a social, human, and environmental point of view. As everyone in the supply chain is responsible to the success of the final product, car manufacturers are the major drivers in the advancement of technology and transformation. To ensure the quality and safety of car users, every supplier of the entire supply chain are required to be certified by standards, such as ISO/TS and IATF.

The strategy map for H Company in adopting smart manufacturing is shown in Figure 2.15. For financial perspective, the first objectives are to increase product margin, utilize capacity with mass production, and invest in new equipment for new product specifications. It requires H Company to build strong customer relationship, even to drive for collaborative production commerce with its key account, and to serve the customers with on-time delivery and the best product offerings. For internal process perspective, the focus should be on

FIGURE 2.15

STRATEGY MAP FOR H COMPANY



value management, process improvement, and technological innovation. In terms of learning and growth perspective, it requires the web-based IT suite, the implementation of lean training, and the introduction of advanced machinery.

The dynamics in related quantitative measures, average unit price (USD), and time to market (days) for H Company toward its smart manufacturing capacity over time is seen in Figure 2.16. As the car industry is under a drastic revolution from petroleum fuel vehicles to electric battery powered ones, it also pushes for more complicated and specialized designs in automotive connectors to keep the vehicle light in weight and ready for transmitting automated guided data. It is expected to increase the unit price as more sensors are integrated into one single connector. As the industrial trend goes, a shorter lead time in developing new car models would put a lot of pressure for suppliers to provide new parts faster. Therefore, for suppliers like H Company, to keep up with the customers' requirements means a shorter time to market its new product designs.

FIGURE 2.16

STRATEGY DYNAMICS IN PRODUCT VALUE AND PRODUCT DEVELOPMENT OVER TIME FOR H COMPANY

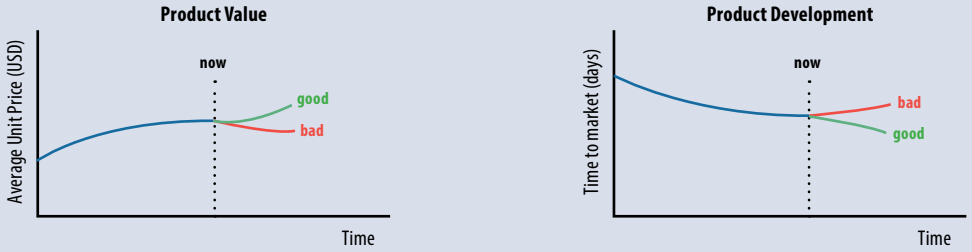
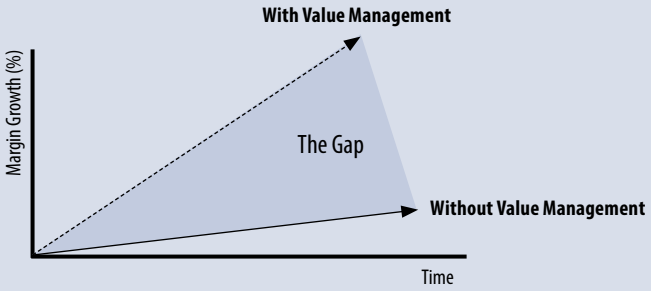


FIGURE 2.17

PERFORMANCE GAP IN MARGIN GROWTH FOR H COMPANY



Advancements in technology have introduced many new features in vehicle designs, and any enhancement in vehicle features significantly increases the use of electronic components. The smart manufacturing strategy in H company would allow a boost in its products' unit price with more complicated designs and a huge reduction in the time to market their new connectors to be adopted by major car companies. The ultimate objective is to keep their overall performance in the company's margin growth sustainable. With the smart manufacturing strategy, the potential improvement in margin growth for H Company is shown in Figure 2.17.

Analysis of Case Study 3: Machinery Component Manufacturing - Yinsh Precision Industrial Co.

Yinsh Precision Industrial Co. is an exceptional SME with strong investment in R&D and manufacturing processes. According to a study by Hsieh, 2014 [18], the model of "workers turned bosses" enabled the growth with equity and the role of SMEs in the ROC economic miracle by 1980s. The research showed that the metal and machinery sector in ROC was highly fragmented. More than 50% of the revenue and value-added was generated by SMEs with fewer than 200 employees from 1996 to 2001, and the number was less than 12% for the IT sector during the same period. The SMEs in machine-tool industry are highly competitive as more than 70% of the products were exported to countries all over the world [18].

A. Economic Alignment

Industrial lock nuts, or industrial fasteners, may be small in terms of volume or cost in high-end, sophisticated industrial products but the consistency and reliability of these parts are paramount. Any quality issue with a small fastener may lead to unexpected machinery shut down, and could cause huge damage in all kinds of production lines. They are applied to three major production markets - automobile, construction, and machinery - and the demand has been strong. The compound annual growth rate (CAGR) has been more than 6% in 2014 to 2018 [19]. Asia-Pacific countries, being the largest production area, provide nearly 40% of all industrial fasteners. It also has the fastest growth rate in all regions, with a CAGR in revenue of 8.7% over these five years.

For machinery industry, especially for advanced, high-end machining solutions, the trend is to complete more manufacturing processes in the same machine with one setup. The trend of multitasking machine, or integrated machine center, would allow 24-7 production schedule with less workers. Yinsh is in good position to deal with this trend of extreme high reliability, high-mix, and low-volume in industrial fasteners.

B. Technology Utilization

You-Chong Wu, Yinsh's president, has not only been familiar with the technical requirement from its major customers, but also a clear idea in market trends. He had even adopted the latest machinery from his major customer, DMG and Mazak, to replace existing CNC machines when upgrading Yinsh's quality and capability. Other than lock nuts, Yinshi has been proactive in trying new technology and machining. Yinsh has its own precision QC lab that is accredited by TAF for advanced test and measurement in torque force and clamp force under vibration condition.

C. Talent Development

Yinsh has been working with local community colleges to keep its workforce trained and educated with the latest technology and quality concepts. Both You-Chong Wu and You-Jie Wu are alumni of National Chin-Yi University of Technology. The collaboration between Yinsh and National Chin-Yi University of Technology is not only in teaching and research, but also in training and recruiting talents from the school under vocational programs. Yinsh provides internship each year, and many of them choose to stay when they graduate. More than a third of the current employees are from the same university.

D. Supply Chain Collaboration and Partnership

One trait of ROC's machine tool industry is that they are SME-based and decentralized [18], and Yinsh keeps a close tie with the cluster of the production network. Most of its suppliers and contractors are long-term partners and all are in the Taichung area. In the late 2010s, Yinsh started to push its suppliers for quality excellence. Yinsh tries to collect basic order execution data manually, such as the inventory of raw materials, incoming inspection, and delivery time to predict lead-time and yield from its suppliers without interference with the suppliers' own system. The data accuracy has been improved gradually as more data were collected and analyzed.

E. Market Competitiveness

Since early 2000s, Yinsh started to transform its strategy from making standardized, low value-added, domestic-market only products to become a global vendor in high value-added industrial fasteners. By 2018, Yinsh made 30% of all industrial lock nuts sold in the world and was ranked the third largest vendor in industrial fastener for high-end machineries, trailing SKF, a Swedish company, and Fukuda Co. (FKD) in Japan.

Yinsh's strength lies in its high customer retention rate. Yinsh is the main vendor for leading companies in high-end machinery, like DMG MORI and Mazak. The close relationship with customers is also helpful in advancing their manufacturing technology. The weakness may lie in the limited resources available for Yinsh to grow rapidly, but it might have strategic advantage for a family-own company. The company's opportunity is from its close ties with major customers, especially when new designs in high-end machinery require special parts that might fit the market trends. The threat for Yinsh is lack of labor. It is a common phenomenon in countries with low birth rate, and ROC is at the bottom of the fertility rate.

To sustain its competitiveness, Yinsh has invested heavily to upgrade its production facilities to keep up with the technical requirement from its customers. It has also built a huge barrier for competitors to win over its clientele. The smart manufacturing project is to continue this effort into full automation and digitalization so that the company can have the flexibility to produce anywhere in different locations.

F. Innovation Ecosystem

Yinsh greatly benefited with external resources by working with universities in the Taichung area. It is open to suggestions from research institutes, like the Precision Machinery Research

& Development Center (PMC), and is able to secure several government-sponsored projects when moving toward its Industry 4.0 strategy. In 2016, Yinsh formed its own strategic alliance, referred to as Yinsh Intelligent Manufacturing Promoting Alliance, to monitor its effort in smart manufacturing. The alliance includes PMC and three local universities. You-Chong Wu also recruited David Liu, a senior consultant, to be the director for this alliance to watch over the entire transformation effort.

G. Strategic Management

Yinsh strives to sustain its competitiveness by solidifying its strongholds by using a high-mix, low-volume production strategy and push its boundaries to the uttermost limits. Especially for high-end and high-margin products, the order quantity could be as low as less than a dozen; it requires Yinsh to keep upgrading its capability to meet the changes in product designs and specifications. The need to mass customization can be achieved and thus enable partial implementation of flexible decision as envisioned in Industry 4.0, or the smart manufacturing strategy proposed by Yinsh.

H. Regulation of Operations

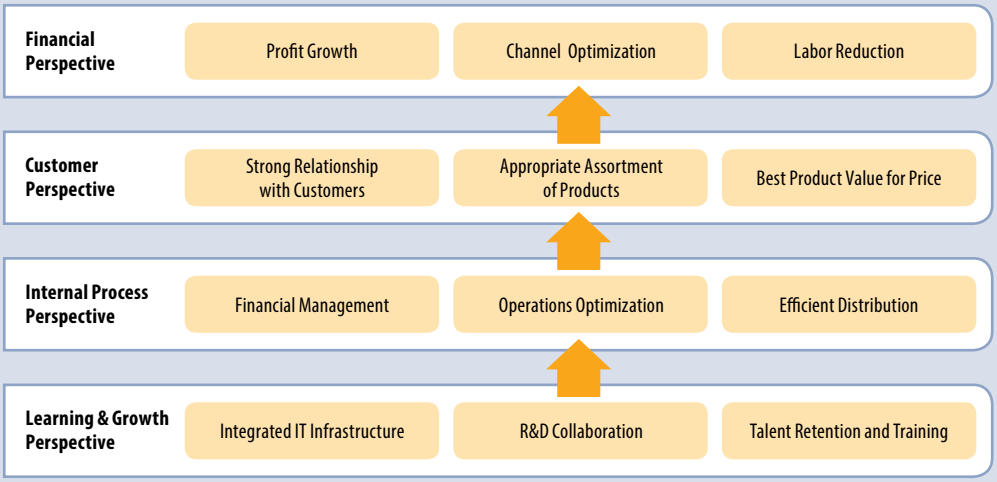
Yinsh is early in identifying the importance of gaining world standard certifications, such as ISO 9001, OHSAS 18001, and ISO 14001. To motivate employees and speed up the organizational changes, Yinsh's president, You-Chong Wu, would lead the effort in person when participating in national-level awards so that it can create a sense of honor and team spirit.

The strategy map for Yinsh Precision Industry Co. is illustrated in Figure 2.18. To keep the momentum for Yinsh to grow, it focuses on three financially related objectives: to increase profitability, to optimize the sales channels, and to reduce the direct labor required. Yinsh needs to create customer values with strong relationship with its key customers, to innovate advanced features with appropriate assortment of products, and provide the best product value with excellent quality that can meet strict specifications. From the internal process perspective, Yinsh's focus should be on financial management, operations optimization, and efficient distribution among its suppliers and customers. The focus for the learning and growth perspective include an integrated IT infrastructure to connect data from SkyMars, MRP, and ERP systems, and customer relationship management (CRM) systems. The collaboration of R&D efforts with suppliers and customers as well as the retention and training of in-house talents are also critical for a SME to remain competitive.

The dynamics in related quantitative measures, in innovation and diversification, and in employee turnover for Yinshi Precision Co. toward its smart manufacturing strategy over time is highlighted in Figure 2.19. To serve customer with high value-added products with performance predictability, it requires Yinsh to focus its smart manufacturing efforts in quality management, production routing management, and real-time production monitoring and control. These upgrades depend on three capabilities: advanced machine capability, production knowledge and skill, and the infrastructure in automation and digitalization of manufacturing process. It requires constant investment in advancing technology. Since the early 2000s, Yinsh has invested heavily on test capabilities by installing 3D inspection machines for quality assurance. It also gradually updated its existing general-purpose machines with multitask machine centers to increase its process capability and routing flexibility.

FIGURE 2.18

STRATEGY MAP FOR YINSH PRECISION CO.

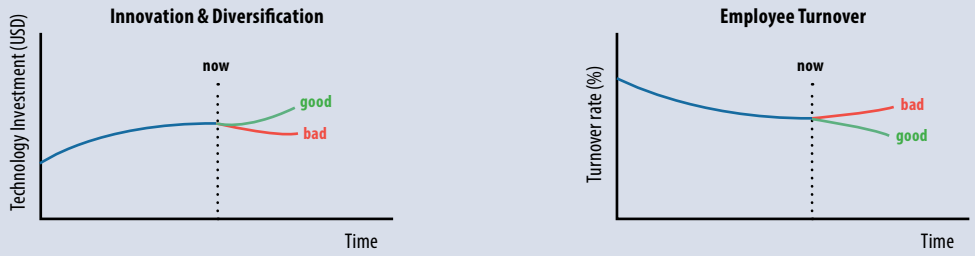


To attract new talents and to keep the turnover rate low, Yinsh is shifting from the traditional, labor-intensive operations toward automated, capital-intensive ones. In 2016, Yinsh started to build IT infrastructure that can automate and digitalize the entire manufacturing process. This smart manufacturing initiative is to allow real-time monitoring and control the process remotely. With digitalized manufacturing data, the system will learn the best production parameters in routing management in smart planning and scheduling in order fulfillment. It leads to higher productivity, and hence higher salary per worker.

During the interview with Liu, the director of Yinsh Intelligent Manufacturing Promoting Alliance, he identified two successful factors in Yinsh's smart manufacturing strategy: better flexibility and high customer satisfaction. For better flexibility, Yinsh aims to increase its

FIGURE 2.19

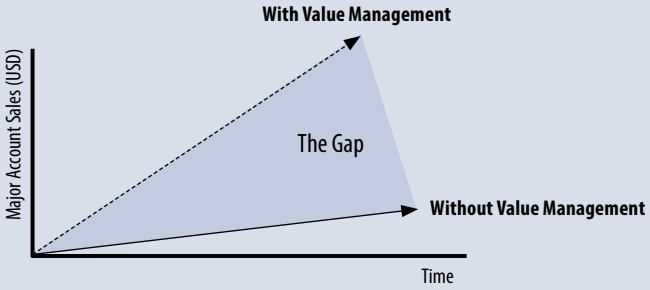
STRATEGY DYNAMICS IN INNOVATION AND DIVERSIFICATION AND EMPLOYEE TURNOVER OVER TIME FOR YINSH PRECISION CO.



equipment utilization while keeping a high-mix, low-volume production requirement. It requires constant improvement in equipment and manufacturing technology, staff training, rapid process routing and scheduling, and product quality. To achieve higher customer satisfaction, a transparency in its manufacturing capability and data would also help in earning trusts from customers. Yinsh tries to satisfy its major accounts by a precise prediction in order delivery, regardless the orders quantity. With the smart manufacturing strategy, the potential improvement in major account sales for Yinsh Precision Co. is demonstrated in Figure 2.20.

FIGURE 2.20

PERFORMANCE GAP IN MARGIN GROWTH FOR YINSH PRECISION CO.



CONCLUSION

In this report, three cases are included to demonstrate transformation strategies in ROC's manufacturing sector. It is usually assumed that there is a universal framework for any company to transform itself for Industry 4.0 and take advantage of the advancement in the latest development in data analytics, IoT, wireless communication, cloud computing, and even augmented reality.

However, as shown in these three cases, none adopted the same IT even though they work towards achieving the same goal. Each case has its own transformation challenges and strategies. As suggested by David Liu, PhD, the Vice Convener of the Intelligent Manufacturing Promoting Alliance in Yinsh Precision Industry Co. Ltd, the assumption of universal transformation model might be unrealistic, even an overstatement for most manufacturers when pursuing a sustainable business strategy.

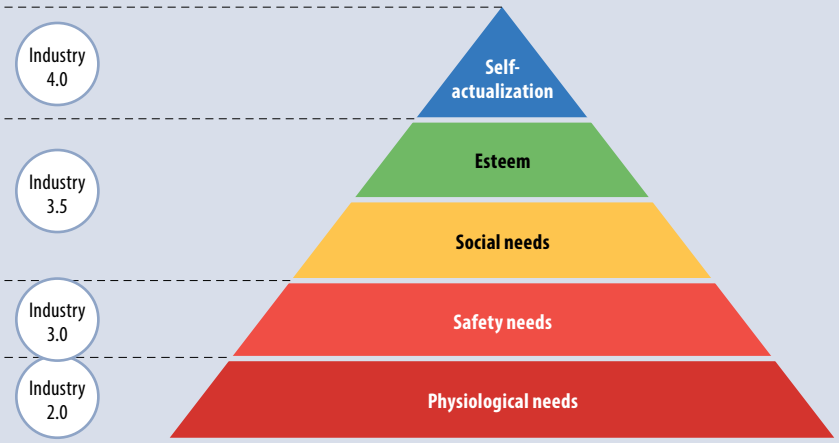
From the policy perspective, different policies should be considered when promoting transformation into Industry 4.0 and smart manufacturing in ROC. Further, the best business strategy for Industry 4.0 might be the one that "best-fit" for the company with the consideration of its size, resources, scope, and the business vision perceived by the business owner and the entire organization; and it could vary dramatically between industries, even between companies in the same industry.

To illustrate the motivation for manufacturers to stay competitive, a five-level manufacturing business strategy is proposed according to the perceived business needs. Similar to the Maslow's

hierarchy of needs, the subtle differences in the perception of the manufacturing transformation needs in any company can be categorized (see Figure 2.21). The objectives, the associated strategies with the "best-fit strategy" in terms of the stage of industrial revolution for each level of a company's perceived needs is suggested as follows:

FIGURE 2.21

HIERARCHY OF NEEDS IN SUSTAINING BUSINESS GROWTH AND THE ASSOCIATED INDUSTRY EVOLUTION STAGE



i) Self-actualization needs

This is the highest level of need for a company to strive in advancing the organization's value propositions that has been set along with the global and universal trends, such as sustainability, authenticity, and humanity. It is to dedicate and heavily invest in the application of top-notch manufacturing technologies for the next-generation needs. The strategies that might be suitable are:

- To invest in resource conserving processes, even in clean-energy technology for advanced manufacturing processes
- To develop open platform to accommodate shorter product life cycle and even to rise the learning curve of new application for customers
- To innovate for new business models

ii) Esteem needs

This is the need for a company to serve as an advocate and a leading role in the industry for appreciation and respect in the society and community. It is to dedicate its resources and effort in advancing manufacturing technologies to meet the highest and strictest specifications in the global market. The strategies that might be suitable are:

- To monitor intensively for potential needs and serve as an active participant in maintaining or even revising standards for the industry
- To remain in the leading position by optimizing its performance in resource utilization, process improvement, and technology differentiation
- To innovate in product offerings, in next-generation material, and in advanced production processes

iii) Social needs

This is the need for a company to become a strong and reliable player in the supply chain and to seek for the ultimate acceptance among vendors and customers alike. It is to find for excellence in striking the balance between utilization and flexibility to build great relationship among suppliers while best serve its customers to maximize its profit. The strategies that might be suitable are:

- To invest in mechanism, such as ERP system that is consistent with suppliers and customers for better communication and coordination
- To constantly improve the flexibility for quick response to changes in the supply chain
- To innovate in better predictability and risk assessment in resource utilization, profitability, and production capability

iv) Safety needs

This is the need for a company to keep up with the market requirement and customer specifications in a cost-efficient way. It is to keep competitive in a global market and remain profitable. The strategies that might be suitable are:

- To invest in basic infrastructure, such as MES system to coordinate production activities to have a full shop floor control
- To constantly improve the capacity utilization with automated machinery and the capability of predictive maintenance
- To innovate in automated data collection, such as barcode and RFID tag

v) Physiological needs

This is the need for a company to just keep up with necessary capability to stay viable. The strategies that might be suitable are:

- To update the manufacturing facility by replacing non-automated features generic machinery with computerized ones
- To reduce the reliance on skilled workers and production costs

To conclude, as illustrated in Figure 2.21, the Industry 4.0 strategy will only make sense when a company has satisfied at least the physiological needs, the safety needs, and the social needs. Both H Company and Yinsh Precision Industrial Co. are beyond their social needs, and are facing their esteem needs with strong foundations. TSMC has just met its esteem needs when it started its Industry 4.0 era in 2018, and is working for the self-actualization needs with its investment in AI and big data analytics.

Another takeaway is the importance of the collaboration among government, academia, and industry to bridge the gap of technology development and application for manufacturers, especially for SMEs. Government-sponsored projects, such as the smart machine box (SMB) proposal, is especially helpful for SMEs to overcome their resource limitation in the manufacturing transformation and upgrades. Other players are involved to speed up the changes in ROC's manufacturing sector. Research institutes, like the Precision Machinery Research & Development Center (PMC) and ITRI, and universities, like National Chin-Yi University of Technology and Taipei Tech, are the companies' best external R&D laboratories' talent pools. Even TSMC has been greatly assisted by ITRI and National Tsing Hua University in its early days and the collaboration remains strong.

CHAPTER 3

INDIA

INTRODUCTION ON INDUSTRY 4.0 APPLICATION AND CONTEXT CONDITIONS

Background of Manufacturing Sectors and SMEs in the Wave of Industrialization

India encompasses skilled people with diversified expert skill sets, availability of varied and huge natural resources, and ample opportunities, depending on the geographical region, socioeconomic profile, and comprise strong business environment (domestic and global). The nation has adopted manufacturing best practices, where small and medium enterprises (SMEs) contribute enormously for its growth. Micro, small, and medium enterprises (MSME) have emerged as a highly vibrant and dynamic sector of the Indian economy over the past five decades. India also has huge market potential for Industry 4.0 which can elevate the nation's economy. There are successful implementation of Industry 4.0 in MSMEs through various regional and national level initiatives by MSME and the government of India. Open-minded learning and healthy competition are the significant factors for the implementation of Industry 4.0 in the country. The key enablers and drivers are illustrated in Figure 3.1 while the background statistics of Indian manufacturing sector and various initiatives are outlined in Figure 3.2.

FIGURE 3.1

INDUSTRY 4.0 KEY ENABLERS AND DRIVERS IN INDIA

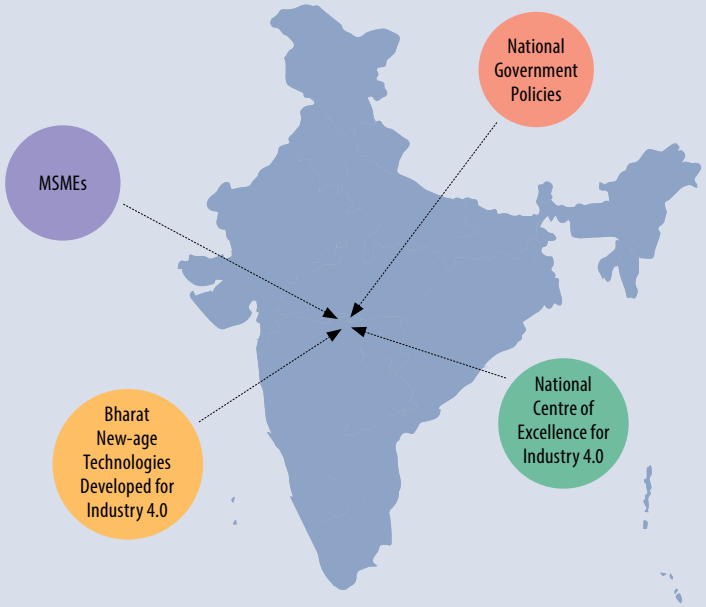
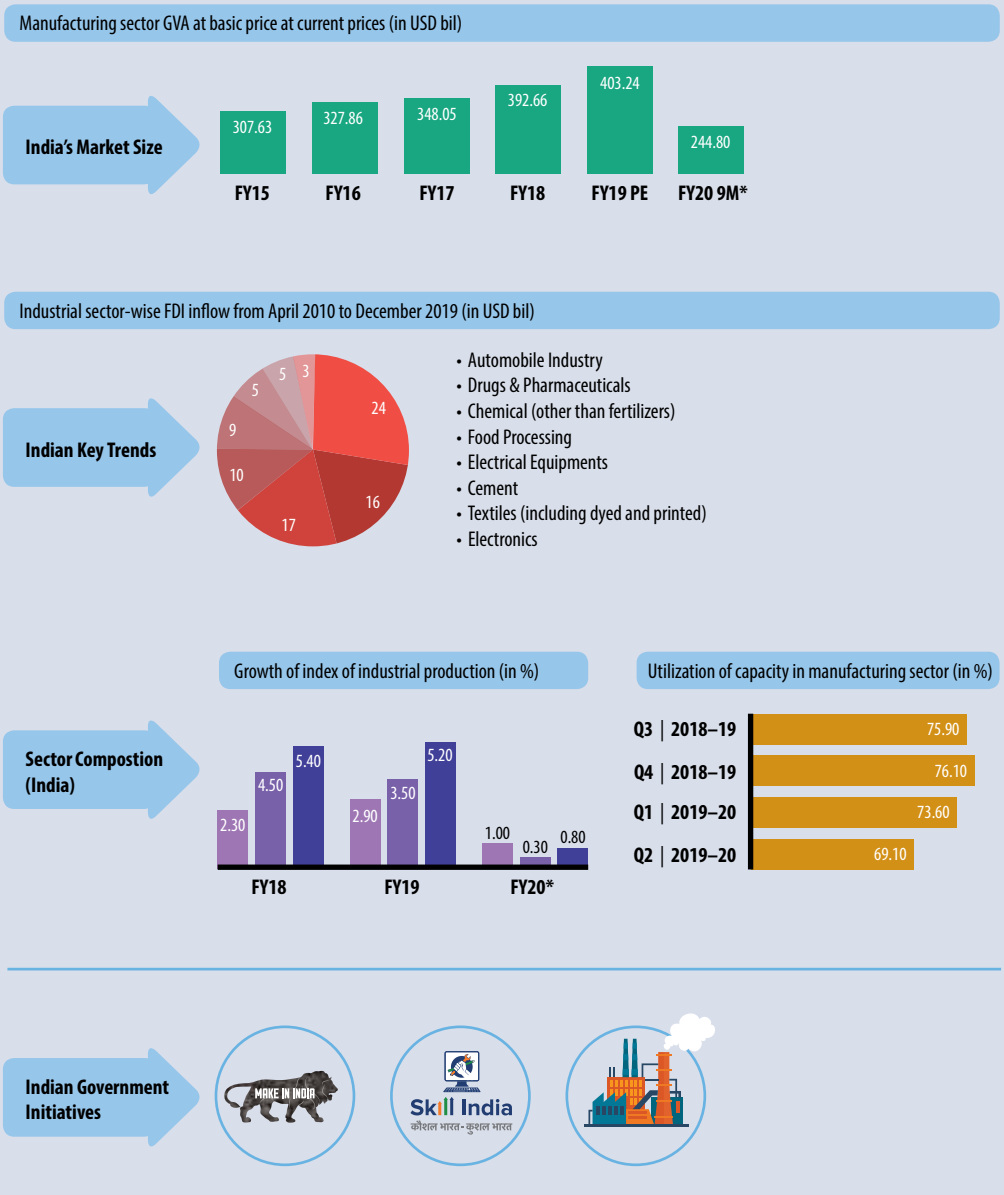


FIGURE 3.2

INDIA'S MANUFACTURING STATISTICS [1]

Indian Manufacturing Statistics



The government's vision is to make India a USD5 trillion economy by 2024, out of which MSME is poised to contribute USD2 trillion.

India is on the threshold of major reforms and is poised to become the world's third-largest economy by 2030. The MSME sector is the strong pillar of India's economy. In 2020, the country has about 63 million MSME players, generating nearly 111 million employment, and manufacturing more than 7,500 products that contribute about 48% in India's total exports. The Ministry of MSME's cluster approach is to create and upgrade the industrial infrastructural facilities of the existing and new MSME industrial units and develop service ecosystems in India. MSME sector contributes 29% to the GDP and 48% to exports.

Technological Innovation, Business Model, and Market Development

A smart approach is vital to connect technological innovations to the market to benefit the stakeholders, especially the MSMEs. Apart from being cost effective, these technologies can also bridge the gaps in the market and substitute direct import. In addition, the sale of these technologies improves India's GDP. The following are the list of new age technologies developed and supported by the government of India. Table 3.1 and Figure 3.3 provide the details of recent innovations in India and the business models for connecting innovation and market.

TABLE 3.1

LIST OF BHARAT NEW-AGE TECHNOLOGIES SUPPORTED AND INITIATED BY DEPARTMENT OF HEAVY INDUSTRIES UNDER CAPITAL GOODS SECTOR [2]

Center of Excellence	Distruptive Smart Technologies Developed	Concept of the Technologies	Technology Initiated by
Centre of Excellence at Central Manufacturing Technology Institute (CMTI), Bangalore (TMMA)	Development of shuttleless rapiers looms of 450 RPM	Picking and beating mechanisms	CMTI, Bangalore, Karnataka
Centre of Excellence at Indian Institute of Technology (IIT), Madras (Advanced Manufacturing Technology Development Centre)	Development of 5-axis multitasking machine Automation of grinding process intelligence Development of 5-axis universal machining center	NA i) Entry into Industry 4.0: IoT-enabled grinding machine ii) Process intelligence	IIT Madras, Tamil Nadu
Centre of Excellence at PSG College of Technology	i) Welding robots ii) Special alloy electrodes iii) Power supply	Development of welding automation products and power sources	PSG College, Coimbatore, Tamil Nadu
Centre of Excellence at Scientific and Industrial Testing and Research Centre (SiTARC)	Development of smart submersible (6 inch) pumping solutions for industrial and water supply applications	Academia, industry, and government	SiTARC, Coimbatore, Tamil Nadu
Centre of Excellence at Heavy Engineering Corporation (HEC) Ranchi	Development of 5CuM hydraulic excavator - HEX 400		HEC, Ranchi
Centre of Excellence at Indian Institute of Science (IISc) Bangalore (Smart Factory)	Development of additive manufacturing machines	Academia, industry, and government	IISc, Bangalore, Karnataka

Government-Academia-Industry Collaborations for Industry 4.0 Application in Manufacturing Sectors

Government of India Initiatives

Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) - Udyog Bharat 4.0 (SAMARTH Udyog) is a unique program of industry, academia, and government collaboration with the main objective to integrate technology and skills advancement in the manufacturing sector. The program sees the collaboration of various academic research institutions with industry and government agencies to promote Industry 4.0 ecosystem in India. It is aimed to stimulate, support, and facilitate SMEs to derive tangible benefits of smart manufacturing.

FIGURE 3.3

BUSINESS MODELS CONNECTING TECHNOLOGICAL INNOVATION AND MARKET

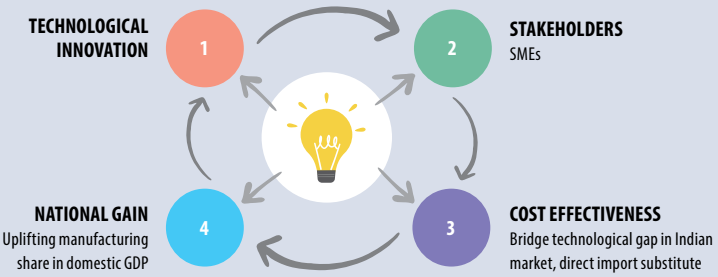
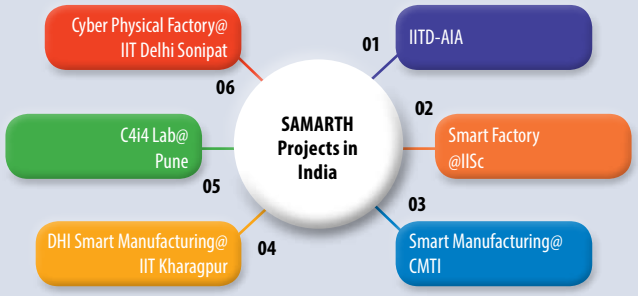


FIGURE 3.4

FOUR COMMON ENGINEERING FACILITY CENTERS ESTABLISHED BY THE GOVERNMENT



SAMARTH Udyog is initiated by the Department of Heavy Industry of the Ministry of Heavy Industries and Public Enterprises to enhance competitiveness in the capital goods sector. This project is to transform India into a smart and intelligent manufacturing hub and put it on the global map.

SAMARTH Udyog has various functions, as the following:

- Conduct campaigns and develop trainers in Industry 4.0
- Establish start-ups and incubation supported by MSME and Niti Aayog (public policy think tank)
- Provide hand-holding support to MSMEs, thereby plan and execute projects relevant to Industry 4.0 that are implemented through consultancy services on fee basis
- Interface and collaborate with academic institutions in proximity, thereby offer training and internship for students and faculty members
- Improve the participation in the platforms supported by the government to implement Industry 4.0 with focused objectives and well-defined agendas
- Actively involve MSME, industrial clusters, and capital goods

The government of India has established common engineering facility centers in the country with the objectives to actively enhance the fourth industrial revolution ecosystem (see Figure 3.4).

i) Establishment of technology and training centres

The government of India has taken the initiative to establish technology and training centers for Industry 4.0 (see Table 3.2).

TABLE 3.2

GOVERNMENT TECHNOLOGY/TRAINING CENTERS FOR INDUSTRY 4.0

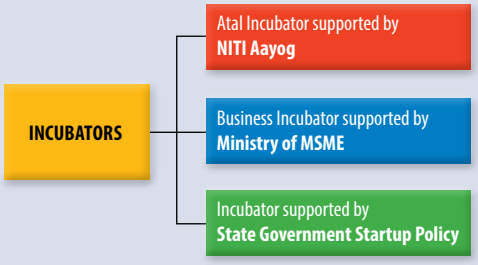
Government Organization	Center for Industry 4.0	Outcomes
Technology Development Centers - MSME (PPDC), Agra under Ministry of Micro, Small and Medium Enterprises	Industrial Automation & Robotics	i) Manpower development and training programs ii) Projects iii) Student internship
National Small Industries Corporation (NSDC), under Ministry of MSME	Augmented & Virtual Reality 3D printing	Training programs
National Productivity Council, under Ministry of Commerce & Industry	Industry 4.0	i) Training programs ii) Projects iii) Demo centers and experience zones iv) Partner with industries to promote Industry 4.0 v) Student internship

ii) Government supported incubators

The government has been promoting incubation activities to encourage more start-ups in various domain of Industry 4.0, such as Internet of Things (IoT), smart manufacturing, 3D printing, cloud computing, and collaborative robots (see Figure 3.5).

FIGURE 3.5

CENTRAL AND STATE GOVERNMENT INITIATIVES OF INCUBATORS THROUGH COLLABORATION WITH ACADEMIC INSTITUTIONS



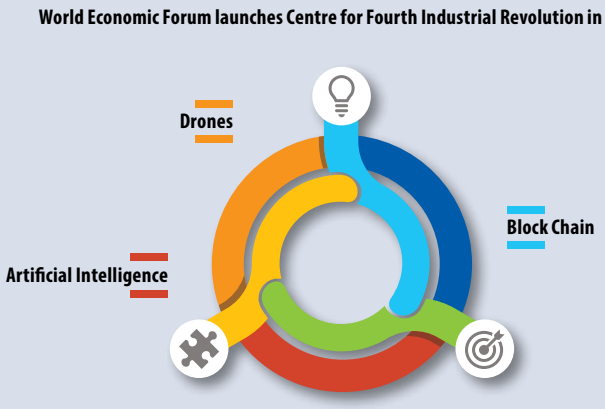
iii) International cooperation for Industry 4.0

India, in partnership with the World Economic Forum, has taken steps to reshape the emerging new age technology policy by establishing a center for Industry 4.0 in Maharashtra (see Figure 3.6).

The center will play a significant role in promoting Industry 4.0 in the country. It will also collaborate with the government to reform and codesign the policies framework on emerging technologies thereby bringing various stakeholders, such as start-ups, academia, and business leaders across India.

FIGURE 3.6

CENTER OF FOURTH INDUSTRIAL REVOLUTION ESTABLISHED BY THE WORLD ECONOMIC FORUM IN INDIA



Industry Associations/Industries

The Confederation of Indian Industry (CII) is a nongovernment, not-for-profit, industry driven, strong industrial association and managed by various stakeholders that include MSMEs. CII has created a smart manufacturing platform which is an industry-driven initiative for Industry 4.0. It works with various agencies from central and state governments, technology drivers and providers, manufacturing industries across India, consulting agencies and consultants, universities, colleges and research institutions, and global organizations to facilitate, promote, and grow Industry 4.0 revolution in the manufacturing industries. CII Smart manufacturing has established several demo centers across India in collaboration with industry partners to showcase and train various stakeholders in the domain of Industry 4.0.

Demo centers established by CII are:

- Marshall Industry 4.0 Center, Manesar, Haryana
- Marshall Industry 4.0, Ludhiana, Punjab
- OMRON Automation Center, Mumbai, Maharashtra
- Siemens Digital Experience and Application Center, Bengaluru, Karnataka
- Rockwell automation digital transformation experience, Gurugram, Haryana
- Siemens India digital factor, Kalwa, Thane, Maharshtra

The other industrial associations that promote Industry 4.0 are PHD Chamber of Commerce and Industries and the Associated Chambers of Commerce and Industry of India (ASSOCHAM).

Contribution by Academic and Research Universities/Institutions to Industry 4.0

The All India Council for Technical Education (AICTEs) under the aegis of Department of Higher Education, Ministry of Human Resource Development is the statutory body and a national-level council that promotes technical education across various states of the country. The various quality research initiatives of AICTEs toward enabling Industry 4.0 education system in India include modelling the curriculum based on essential technologies of Industry 4.0. Online courses are also provided for students and faculty members (National Education for Alliance Technology (NEAT), and AICTE Training & Learning Academy (ATAL)). Unique initiatives to interface the academic institutions with the government are carried out by establishing centers of excellence in institutions (see Table 3.3).

TABLE 3.3

CENTER OF EXCELLENCE IN INDUSTRY 4.0 IN ACADEMIC INSTITUTIONS SUPPORTED BY THE GOVERNMENT

Center of Excellence	Government Initiatives	Purpose	Domain of Industry 4.0 & Outcomes
Welding engineering technology at PSG College of Technology, Tamil Nadu	Part of 'Make in India' movement, this scheme is financially supported by the Department of Heavy Industries (DHI). This scheme is being implemented by DHI under the public-private partnership.	i) To promote Industry 4.0, especially in the manufacturing technologies of welding ii) To accelerate the growth of capital goods iii) To develop new technologies in the field of welding	Design & Development of arc welding robot
Smart manufacturing at Dhronacharya Engineering College, Greater Noida	Initiative by MSME (PPDC), Agra - Technology Development Center	To promote and train young budding engineers in the area of smart manufacturing	Smart manufacturing
Advanced computing, product design, automation & robotics at TIFAC-CORE (Centre of Relevance and Excellence) i) Ajay Kumar Garg Engineering College, Ghaziabad ii) SASTRA University, Tamil Nadu iii) PSG College of Science & Technology	Technology Information, Forecasting and Assessment Council (TIFAC) under Department of Science & Technology	Product design & development	Product design & development

Governmental Policies and Business Environment for Industry 4.0

'Make in India' is an important initiative by the government that fosters the best-in-class manufacturing infrastructure (see Figure 3.7). The initiative's major focus is on the wider and stronger adoption and best practices of Industry 4.0 in the country. The 'Make in India' program has been in the forefront to boost investments as well as to improve manufacturing processes in MSME and different sectors. In fact, it provides strong support for small and large companies to establish and develop smart and advanced manufacturing infrastructure and capabilities through technology upgrade investments as well. It has made an impact on the whole, especially significant improvements in Doing Business ranking across the globe. India's ease-of-doing-business ranking was at 63 in 2019 among 190 countries, moving forward 14 places from its previous ranking of 77th in 2018. Simultaneously, India secured a score of 71.0

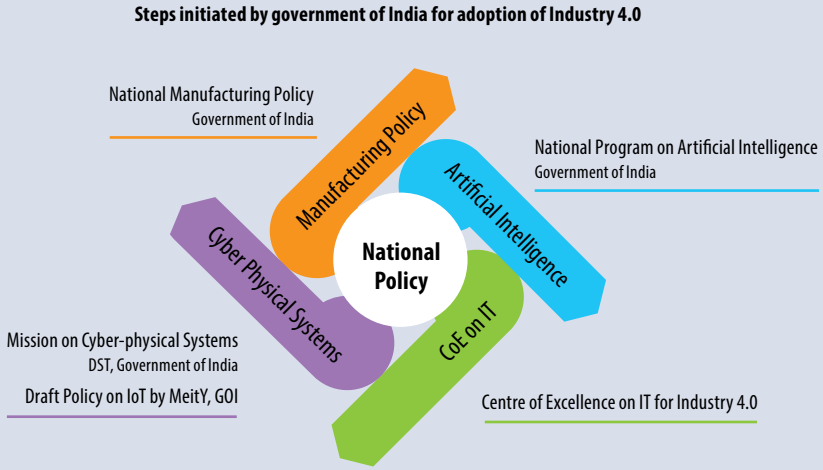
from 67.23 compared to the previous year. India is also listed as one of the 10 largest economies for the third consecutive year.

FIGURE 3.7

OBJECTIVES OF 'MAKE IN INDIA' PROGRAM IN MANUFACTURING SECTORS

FIGURE 3.8

NATIONAL POLICIES TO FACILITATE AND PROMOTE INDUSTRY 4.0 ECOSYSTEM



Indian National Policy Frameworks to Enable Industry 4.0

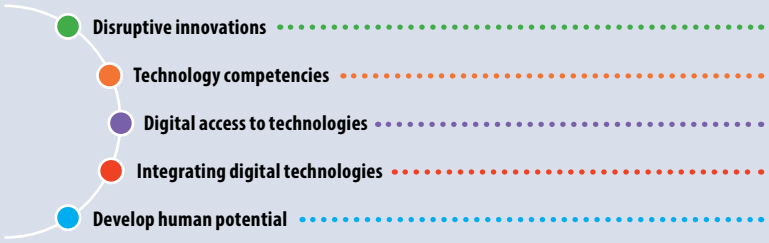
To enable the Industry 4.0 ecosystem in India, the government has initiated and reformed policies for manufacturing and technologies through regulatory frameworks and forming a policy environment that is more conducive thereby developing competitiveness in the manufacturing process. In addition to 'Make in India', several policy frameworks were rolled out to utilize the potential of emerging and essential technologies of Industry 4.0 and make India an advanced global leader too. National policies

were initiated on different domains, like cyber-physical systems, IoT, AI, national manufacturing policies, and policy on digital transformations.

National policies are aimed in developing and building several ecosystems for Industry 4.0 with the following focused objectives and outcomes, as shown in Figure 3.9.

FIGURE 3.9

OBJECTIVES AND EXPECTED OUTCOMES (GENERALIZED) OF THE NATIONAL POLICIES



i) Scheme/National policy framework 1: Promotion of digital enterprise - Digital MSME scheme [3] for the promotion of ICT in MSME sector

The MSME is a vibrant sector and the backbone of the national economy. Despite its enormous success, the MSME sector has been facing many challenges in the last few years but has managed to transform them into considerable opportunities, especially in ICT.

In order to face domestic and global competition, the MSME took a major initiative with the use of ICT among different facets of businesses across different sectors. The adoption and best practices of ICT are the key enablers to product and delivery thereby having control of the inventory and lowering the process cost which supports the Management Information Systems.

The concept of the scheme is the adoption and implementation of cloud-based approach that emerged as cost effective and time saving.

ii) Scheme/National policy framework 2 [4]: National mission on interdisciplinary cyber-physical systems (CPS)

This initiative was implemented through the Ministry of Science and Technology (Department of Science & Technology) with an outlay of INR36.6 billion (INR3,660 crore) for a period of five years. The objective of the policy is to establish and create an ecosystem which is seamless through the various new-age CPS technologies. This will coordinate and integrate nationwide efforts for generation and sharing of knowledge, development of human resources (upskilling and reskilling), R&D, development of technologies thereby enabling products and promoting a culture of innovation and technology commercialization.

The policy to promote and enable Industry 4.0 in India is featured to do the following:

- Knowledge generation
- Products and technological developments

- Skill development (reskilling and upskilling)
- Start-up and entrepreneurship
- Domestic and international collaborations

iii) Scheme/National policy framework 3: National manufacturing policy [5]

The Department of Industrial Policy & Promotion under the Ministry of Commerce & Industry declared that the national policy framework for manufacturing will create a huge employment opportunity of up to 100 million jobs. It is in line with the department's focus to enhance and improve the contribution of manufacturing to the GDP by 25% within 10 years. The policy is centered to enrich the skill sets of rural youth, enabling them to be more employable as well. The core of the manufacturing policy is the sustainable development of different manufacturing sectors with a special target to create value addition in terms of technological manufacturing ecosystem.

A snapshot of the policy:

- Incentives: To offer manufacturing incentives for SMEs
- Skill training: To empower the youth by imparting industrial skill-based training to reskill and upskill (job creation)
- Business regulation: Simplify and rationalization
- Closure: Simple and easy exit policy
- Technology upgradation: To facilitate green technologies
- Manufacturing zones: Creation of national investment and manufacturing zones
- National policy for advanced manufacturing

The instruments of the policy are as following:

- Flagship initiative of Department of Heavy Industries
- Framework for the introduction of Industry 4.0
- Increase the GDP from 16% to 25% through manufacturing output
- Major focus to address the global manufacturing competitiveness by adopting best practices of Industry 4.0
- To increase technological depth (advanced materials, advanced robotics, and 3D printing)

iv) Scheme/National policy framework 4: National policy on IoT

NASSCOM's (National Association of Software and Service Companies) Centre of Excellence for IoT is the flagship initiative of the Ministry of Electronics & Information Technology (MeitY) under the

Digital India program to promote and facilitate the growth of IoT start-ups. By utilizing the potential of India's strength in IT, the aim is to achieve leadership in the domain of hardware and software. The center focuses on harnessing and leveraging the potential of IoT start-ups and contribute significantly to Industry 4.0. MeitY has framed the IoT policy to facilitate its growth and potential in India.

Significant Outcomes of Industry 4.0 Implementation in India

India has initiated national policy frameworks for the implementation of Industry 4.0 and resulted in significant outcomes (see Figure 3.10 and Table 3.4).

FIGURE 3.10

SIGNIFICANT OUTCOMES OF NATIONAL POLICIES ON INDUSTRY 4.0

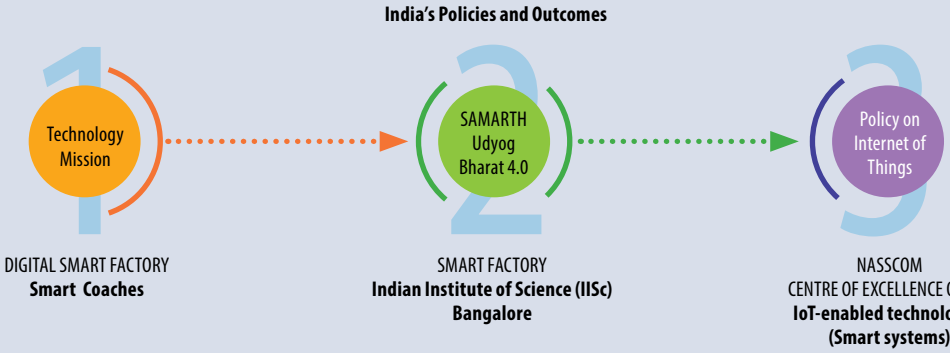


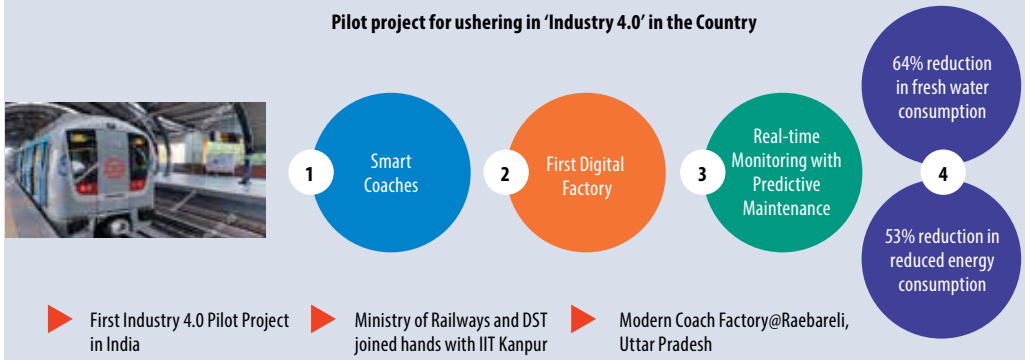
TABLE 3.4

SIGNIFICANT OUTCOMES OF NATIONAL POLICIES ON INDUSTRY 4.0 IN INDIA

National Policy	Government of India	Flagship Project	Outcomes
Technology mission for Indian railways	Ministry of Human Resource & Development and Ministry of Science & Technology	Modern coach factory, Raebareli	Smart coaches (see Figure 3.11)
SAMARTH Udyog Bharat 4.0	Department of Heavy Industries, Ministry of Heavy Industries & Public Enterprises	Smart manufacturing systems	Smart Factory at Indian Institute of Science, Bangalore
Smart cities mission	Ministry of Urban Development	100 smart cities	917 projects completed and 1,911 ongoing
NASSCOM Centre of Excellence in IoT & AI	Ministry of Electronics & Information Technology	IoT & AI	Start-ups on IoT and AI incubated and contributing for Industry 4.0
Scheme for Enhancement of Competitiveness in Capital Goods Sector	Department of Heavy Industries, Ministry of Heavy Industries	Three technology development projects Eight Centre of Excellence	i) CoE at CMTI ii) CoE at IIT, Madras iii) CoE iv) COE at Coimbatore by SiTARC v) CoE at IIT Delhi vi) CoE at IIT Kharagpur vii) CoE at HEC, Ranchi viii) CoE at IISc-Bengaluru

FIGURE 3.11

INDUSTRY 4.0 PILOT PROJECT IMPLEMENTED UNDER TECHNOLOGY MISSION



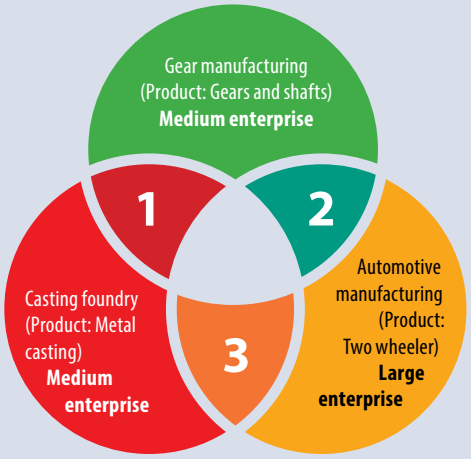
SUCCESSFUL BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

Sectoral Coverage

The case studies consist of three manufacturing sectors that outlines the potential of manufacturing products in India (see Figure 3.12). The first case study is on the casting foundry (India's foundry industry is the second largest in the world). The foundry market in India from 2018–23 is expected to expand at a compound annual growth rate (CAGR) of 12.7%. The second case study looks at the gear manufacturing industry where it is anticipated to grow at a CAGR of 9.44%. The third case study is on the automobile industry. India's commercial vehicles sales are expected to reach a volume of 2,059,950 units by 2024, expanding at a CAGR of 15.23% in FY2020–24.

FIGURE 3.12

SECTORAL COVERAGE OF INDUSTRIES CONSIDERED FOR CASE STUDIES



CASE STUDIES - AN IN-DEPTH LOOK

Case Study 1: Manufacturer of Metal Components [5]

Overall description of the company is obtained from the company's annual report 2017–19.

Description of the Company/Industry	Qualitative Information	Reference
Name of Company	Manufacturer of metal components	
Type of Industry	Medium enterprise	
Year of Establishment	1963	
Number of Employee (FTE)	1,000	
Product/Industry	This company is a pioneering leader in designing and developing metal components through collaborations with the government with an advanced manufacturing facility in India. The company is a global supplier of high precision metal components (foundry components, such as casting products) for applications in manufacturing industrial operations, especially in the steel and marine, oil and gas, paper and pulp, and aerospace industries. The company develops precision components for Indian public-sector companies, such as Bharat Heavy Electricals Limited, BEML Limited, and India's premier space program. More than 80% of the products are manufactured in India and supplied across the globe - European Union, USA, and other countries.	

Highlights of Case Study 1:

Measurable Parameters	Qualitative Information	Qualitative Information	Expert Opinions	Reference
Economic and industry environment	Indian foundry industry is the 2nd largest in the world	Currently produces 12 million ton of cast components with an annual turnover of USD19 billion		
Business strategy function	Collaboration on technology, investment on technological infrastructure, global market, quality standards	NA		
Business model	Sustained business model	Exports 80% of products manufactured in India		
Innovation/core smart technology	Robotic-assisted manufacturing, 3D printing, rapid prototyping, virtual tooling	NA		
Product innovation	Casting and forging re-form, titanium casting technology, and manufacturing capability is brought to India within this facility	NA		
Collaboration	Department of Science & Technology, Ministry of Heavy Industries, Castings Technology International (CTI) - a research and technology organization based in the UK	INR100 million (2016–17)		Obtained from the company's annual report 2017–19
Infrastructure	Establishment of world-class advanced manufacturing facility in Lucknow, Uttar Pradesh	75,000 sq mt of land, 15,000 sq mt of infrastructure building		
Human resource management	Highly skilled, talented manpower - well trained on latest advanced manufacturing technologies	Employs over 1,000 people		

Measurable Parameters	Qualitative Information	Qualitative Information	Expert Opinions	Reference
Customer relationship after sales services	IT supported system			
Domestics sales (Revenue)	Strong domestic market because of the growth of metal casting industries in India	14–20% growth in India in FY19		
Global sales (Revenue)	Revenue generated from UK and USA	80% of the revenue gets generated from global value chain		
Financial perspective (Market share, others)	BSE index gainer in FY19	FDI investments in Uttar Pradesh having the marks of USD7 million, which is basically funded by International Finance Corporation and CDC		

Case Study 2: Gear Manufacturer

Overall description of the company throughout the case study is obtained from the company's annual report 2017–19.

Description of the Company/Industry	Qualitative Information	Reference
Name of Company	Gear manufacturer	
Type of Industry	Medium enterprise	
Year of Establishment	1986	
Number of Employee (FTE)	1,000	
Product/Industry	This company is a medium-enterprise gear manufacturing company. They are market and global leaders in technologically innovating automotive gears and shafts through best practices of digitized manufacturing process and lean and agile complete value chain. The company has entered into technical tie-ups with Kyush Mushashi, a subsidiary of Honda Motors, Japan. The company adopts sustainable manufacturing model with optimization in wastage through redesign, reuse, and recycle philosophy.	

Highlights of Case Study 2:

Qualitative Information	Reference
The company has registered a total turnover growth of 20.21%, achieving a total profit before tax (PBT) that recorded an increase of 9.78%	Company annual report 2017–19
Reduction in manufacturing lead time due to lean manufacturing and operational excellence	NA
Embracing new-age disruptive technologies for smart manufacturing	NA
Innovation in process of manufacturing with robots assembly	NA

Case Study 3: Motorcycle Manufacturer

Overall description of the company throughout the case study is obtained from the company's annual report 2017–19.

Description of the Company/Industry	Qualitative Information	Reference
Name of Company	Motorcycle manufacturer	
Type of Industry	Large enterprise	
Year of Establishment	1945	[6]
Number of Employee (FTE)	4,800	[6]
Product/Industry	This company comes from an Indian brand automotive industry and is the third largest motorcycle manufacturer in India. The company, through its innovative business strategies and practices, creates well-engineered competitive range of products and adopts standardized automation solution for the manufacturing process. The company has a strong hold on domestic and global presence. The company continuously upgrades its product-to-product through its strong R&D and in-house advanced infrastructure. The company empowers 50% of the women workforce to work on assembly lines with process automation, such as collaborative robots (Cobots). The company has well-balanced scorecard starting from design through manufacturing practices and customer relationship management that lead to inclusive growth of the organization.	[6]

Highlights of Case Study 3:

Qualitative Information	Quantitative/Qualitative Information
The company has standardized the automation solutions through adopting the best practices of smart manufacturing. This resulted in the company's technological and financial growth	As per the company's FY19 Annual Report financial highlights: i) The company's total turnover has increased by 18.5% to INR318.99 billion (INR31,899 crore) ii) The company's total operating income (net sales plus other operating income) grew by 20.1% to INR30.54 billion (INR30,540 crore). The obtained operating income is the company's highest iii) The Operating EBITDA has also increased by 4.7% to INR5.38 billion (INR5,387 crore) iv) PBT after exceptional items iv) Profit after tax (PAT) increased by 14.9% to INR4.67 billion (INR4,675 crore). The PAT is the highest ever achieved **Conclusion:** The overall performance in terms of the financial highlights is the company's best ever achievement
Talent development through Total Productive Maintenance Training (TPM) training	In FY19, more than 4,800 employees were trained for TPM. A total of 311 Training Programs were conducted, spanning man-day of 7,900 in the whole year (company's annual report 2017–19).
Adoption of collaborative robots and autonomous guided vehicles usage in manufacturing	i) The cost reduction was achieved in the range of 30%–40% ii) Increase in productivity by 58% (Company's annual report 2017–19)

Definition of Success

Case Study 1: Manufacturer of Metal Components

Key performance indicators

i) Adopting Industry 4.0 and its transformation technologies

- The company has framed its policy to adopt smart manufacturing essential technologies of Industry 4.0 to align with the national and global practices of manufacturing

- The company strongly believes in and is committed to growth with product innovation and manufacturing sustainability by pioneering on the disruptive technologies of Industry 4.0
- The company looks at Industry 4.0 to enhance product quality, manufacturing process, strengthen the customer relationship, and improve the complete value chain

ii) Benefits for the company in applying Industry 4.0 and manufacturing transformation

- Business (financial) growth through gains in domestic and global value chain
- Experience enormous improvements in the product and process quality
- Maintain a well-balanced scorecard starting from the concept of innovation, delivering socioeconomic solutions, and supporting the customer relationship
- By adopting Industry 4.0, the company becomes a part of the national and global mission

TABLE 3.5

SUCCESSFUL PLANNED STRATEGIC OBJECTIVES FOR CASE STUDY 1

Information here is obtained from the company's annual report 2017–19.

Planned Strategic Objectives	Qualitative & Quantitative Data
Financial Perspective	**i) Grow sales:** The company has registered a turnover of INR1.51 billion (INR151 crores) in FY19, 50% higher than the growth in FY18 **ii) Maximum profit:** The company has successful achieved sustainable profitable growth by achieving 47% increase in PAT from INR74.4 million (INR7.44 crore) in FY18 to INR109.2 million (INR10.92 crore) in FY19. The company's 80% profit generated from global value chain **iii) Manage investments:** The company has successfully managed its investments by establishing advanced manufacturing world-class facility to innovate product development and implement smart manufacturing. Also, the company successfully invested the funds obtained from the government of India by innovating socioeconomic products
Customer Perspective	**i) Improve brand awareness in Europe:** The company has a successful global value chain by taking the initiative to grow its business in the European Union. International collaboration with International Casting Technology in UK has created successful awareness in Europe **ii) Enter midmarket segment in Europe:** The company has strengthened its business in Europe by achieving a revenue of 65% sales from European Union **iii) Build strong relationship with top customers:** The company has reputable customers across the globe, such as Rolly Royce, Siemens, Flowserve, Tyco, Metso, and Alstom. The company has served successful nation-building public-sector companies, such as Bharat Heavy Electrical Limited and Bharat Earth Moving Limited
Internal Process Perspective	**i) Market intelligence:** The foundry industry is one of the largest manufacturing industries in India and has strong potential to develop casting products to cater to the needs of different industries, ranging from oil & gas, aerospace, marine, steel, and construction **ii) Optimize the process in the plant:** The company has successfully optimized the process through continuous innovation in technologies and create the standardization of manufacturing transformation **iii) Innovate and integrate products:** The company has strong in-house R&D value chain to support product innovation. It has a successful collaboration with the government and continuously innovate its products to meet customer demands and market requirements. The company established advanced manufacturing facility to support the manufacturing transformation strategies of Industry 4.0

Planned Strategic Objectives	Qualitative & Quantitative Data
Learning and Growth Perspective	**i) Implement IT Suite:** The company uses tools, such as quality assurance software and AI-based workstation to deliver to its business partners. The company utilizes enterprise resource planning (ERP) system, business process reengineering tools, and competitive and comprehensive customer relationship management tools to facilitate the customer to access data **ii) Roll out lean training:** The company conducts in-house lean and TPM training to upskill and reskill the human workforce **iii) Improve internal communication:** The company has robust mechanism and channel to communicate internally across the peers of the organization

Objectives:

i) Financial perspectives

This company has the following financial objectives:

- To become the market leader in the foundry industry in both domestic and global markets
- To achieve business growth both in terms of revenue (sales) and profit
- To manage and plan the investments for product and process development
- To meet the demands of the customer and strengthen the customer relationship

Outcomes/success of financial objectives

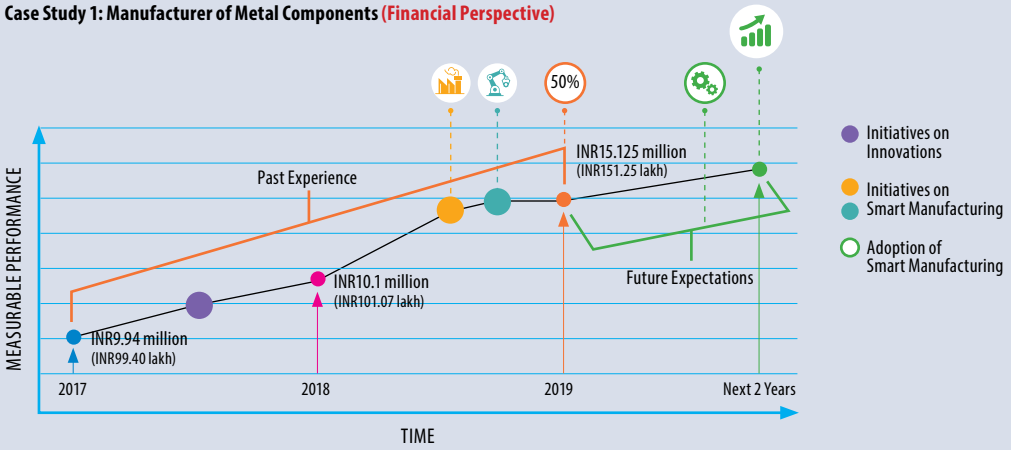
Analysis:
Step 1

- The company achieved a revenue (sales) of INR1.51 billion (INR151.25 crore) in 2019 as compared to INR1.01 billion (INR101.07 crore) in 2018 and INR994 million (INR99.40 crore) in 2017 (see Figure 3.13)
- A business growth of 50% was registered in FY19
- The company has successfully achieved sustainable profitable growth by achieving a 47% increase in PAT from INR74.4 million (INR7.44 crore) in FY18 to INR109.2 million (INR10.92 crore) in FY19. The company's 80% profit was generated from its global value chain
- Funds generated from government agencies was utilized to develop its product innovations. The company invested on infrastructure by building an advanced manufacturing facility as part of its Industry 4.0 manufacturing transformation

FIGURE 3.13

FINANCIAL PERSPECTIVE IN FY17–19

Case Study 1: Manufacturer of Metal Components (Financial Perspective)

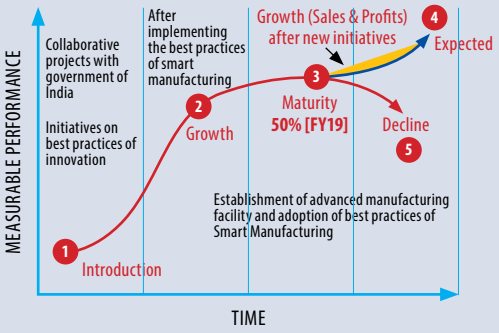


Source: Annual Report

FIGURE 3.14

GENERAL FINANCIAL PERSPECTIVES

Case Study 1: Financial Perspective



Step 2

- The company is able to perform successfully in terms of sales and profit as observed from FY17–19 (see Figure 3.14)
- Sizeable figures in terms of sales and profit was achieved and the trend is the same in the business growth in terms of financial perspectives
- The company is expected to achieve a sizeable mark in the upcoming years if it continues to perform in the similar manner (FY19)

- Robust strategies are already designed in terms of investments on new disruptive technologies for product and process innovation

- The driving forces for the current performance of the company are its strong in-house R&D, joint collaboration with the government on projects to develop product innovations, and continuously adopting Industry 4.0 digital manufacturing transformation technologies

- The disadvantageous factors that may hurt the performance of the company are the non-implementation of Industry 4.0 technologies and fails in product innovations. Also, if there is no utilization of quality tools for monitoring product innovations and customer relationship management

Step 3

- Sufficient cashflow to invest on new technologies and infrastructures has been generated. It also caters to the needs of the human workforce and Corporate Social Responsibility

- The company has achieved a sufficient market share which can be witnessed from the BSE index

- The company is able to manage its inventory which was raised by 15% in FY19 due to investment of development of new products

- A profitable figure was achieved in FY19 as compared to FY18 and FY17 through sales in domestic and global market

ii) Nonfinancial perspectives (internal process perspectives)

The company has a well laid-out plan for its nonfinancial objectives by investing in technological innovation and establishing manufacturing facilities, integrating products, and optimizing the process as well. The nonfinancial objectives are:

- Planned collaboration with the government to develop innovative casting products

- By collaborating with the UK's International Casting Technology to bring the technology to India, the company has global footprint

- To establish an advanced manufacturing facility to adopt the pioneering practices of manufacturing transformation of Industry 4.0

Outcomes of planned objectives:

- Obtained government funded project to develop casting products. The company has received the government's recognition for its R&D lab (see Figure 3.15)

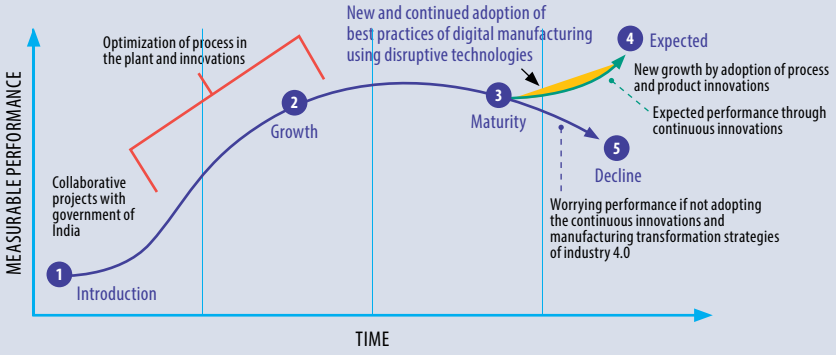
- Successfully customized and developed casting products by importing UK technology

- Developed high value customized range of quality products by establishing the advanced manufacturing facility

FIGURE 3.15

GENERAL NONFINANCIAL PERSPECTIVES

Case Study 1: Nonfinancial Perspective: Internal Process Perspectives



Interpretations from Figure 3.15:

The figure demonstrates clearly the technological growth of the company in terms of product innovations and manufacturing process. The conclusion are as follows:

- The company initially began with the vision to continuously innovate its products. Thus the company started achieving growth by adopting innovations (see Figure 3.15 - 1)
- Innovative products were developed by collaborating with the government by understanding the needs of the domestic and global markets (see Figure 3.15 - 2)
- Invested on manufacturing infrastructures to develop and customize the products to meet the demands of the different industries and segment locally and globally
- Establishing advanced manufacturing infrastructure based on Industry 4.0 philosophy, a paradigm shift took place which led the company to further growth (see Figure 3.15 - 3)
- Achieved high quality products with reduced throughput time after adopting manufacturing transformation ideas
- Adopted sustainable manufacturing model to reduce waste, reuse, and recycle
- Introduced new products by adopting manufacturing transformations and introduce high quality small volume products
- Achieved manufacturing competitiveness through digitalized manufacturing transformations
- Enhance talent development by reskilling and upskilling on various Industry 4.0 technologies
- Learning from past experiences (innovations, technology utilization, talent development, and market competitiveness) and with strategies in place (Balanced Scorecard, strategy dynamics, quality factors, and gap analysis) for a planned, structured business strategies aligned with sustainable manufacturing transformation practices of Industry 4.0

- Has future expectations by following the same philosophy of product innovations and adopting Industry 4.0, and further plans to invest on disruptive technologies, solutions, and services to further strengthen the manufacturing ecosystem (see Figure 3.15 - 4). The company expects to grow in the development of casting products and will continue to stand as one of the pioneering leaders of casting technologies

- The company will decline steeply if it does not adopt the manufacturing transformation strategies of Industry 4.0, maintain the high value quality of the product, increase manufacturing competitiveness, integrate product development with customer service, adopt to changes in technological advancements, further strengthen partnerships (especially with vendors and suppliers), have sustainable manufacturing practices, and lastly, lack vision on domestic and global value chain. The company is fully aware of the conditions for decline in growth technologically (see Figure 3.15 - 5)

Step 4 (gap analysis)

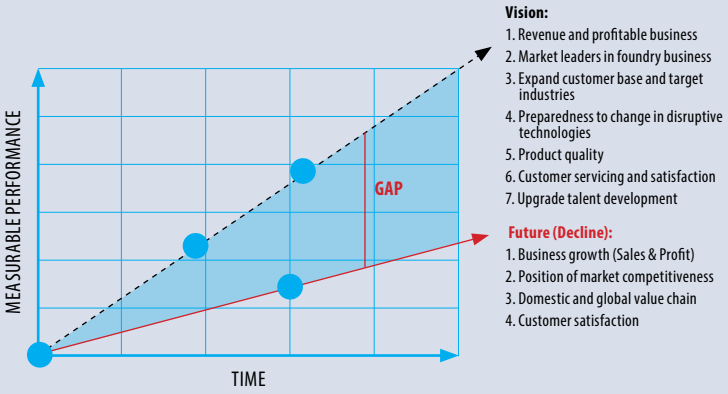
Case Study 1

- **Potential (Vision):** The company has long-term vision to further grow on sales and profit and maintain the position of market leaders in the casting business. The company is prepared to change in disruptive technologies of Industry 4.0. The customer and industry base is also increased. The company plans to focus more on product quality and aims to align its manufacturing practices with strong business strategies. The objective is also to enhance customer service and satisfaction. The gap analysis of the company is illustrated in Figure 3.16

- **Performance (Where will the company head to if it does nothing):** The company will lose its market leadership position and profit. There will be a decline in domestic and global value chain if the company does not perform well by adopting the digital manufacturing transformation strategies of Industry 4.0. Talent development may be lost if the company is lacking in technological utilization as well as not able to contribute to the national and global economy. It would inevitably lead to loss of customers/target industries (see Figure 3.16)

FIGURE 3.16

GAP ANALYSIS



Case Study 2

Key performance indicators

i) Adopting Industry 4.0 and its transformation technologies

- The company intends to adopt Industry 4.0 to meet the demands of customers and market
- The company commits to achieving product quality and enhances process sustainability with Industry 4.0 transformation
- The company has the vision to build strong customer relationship with Industry 4.0 technologies
- The company has the goal to be a strong domestic and global player in manufacturing products
- The company being a medium enterprise sets a benchmark in the manufacturing products
- The company tends to adopt Industry 4.0 to gain manufacturing excellence

ii) Benefits for the company in applying Industry 4.0 and manufacturing transformation

- Able to achieve domestic and global footprints when using Industry 4.0 technologies in product innovation and manufacturing process
- Achieve, grow, and move up the value chain by manufacturing high value, quality, and competitive products
- Create job and employment opportunities
- Able to upskill and reskill the human resources
- Achieve operational excellence
- Able to empower the talent development and strengthen customer relationship

TABLE 3.6

SUCCESSFUL PLANNED STRATEGIC OBJECTIVES FOR CASE STUDY 2

Information here is obtained from the company's annual report 2017–19.

Planned Strategic Objectives	Qualitative & Quantitative Data
Financial Perspective	**i) Grow sales:** The company successfully obtained a revenue of INR6.47 billion in FY19 as compared to INR5.38 billion in FY18. The company has witnessed a business growth of 22.75% **ii) Maximum profit:** The company's PAT is INR354.84 million in FY19 that turns out to an increased growth of 11.19% **iii) Manage investments:** The company expanded its operation by establishing state-of-the-art manufacturing facilities in India. It also created a group of companies to expand varied operations to cover different products and services

Planned Strategic Objectives	Qualitative & Quantitative Data
Customer Perspective	**i) Improve brand awareness overseas:** The company has global footprints in the USA and Canada. The company also plans to start acquisitions in the UK as well **ii) Enter midmarket segment in Europe:** The company has envisioned to expand its operations in the UK through acquisitions **iii) Build strong relationship with top customers:** The company maintains strong relationships by aligning planned business strategies with top customers like Hero Motor Corp, Maruti Suzuki, Tata Cummins, Komotsu, JCB India, and New Holland
Internal Process Perspective	**i) Market intelligence:** The company manufactures gears and shaft which primarily finds applications in automotive industry. The automotive industry in India is the largest and continues to grow. Nearly 8% of the share is spent in R&D **ii) Optimize the process in the plant:** The company optimizes the manufacturing process by adopting pioneering practices of smart manufacturing technologies thereby meeting the demands of high quality product development **iii) Innovate and integrate products:** The company constantly explores the possibility of innovating their products according to the socioeconomic needs and has a strong in-house design team to support the development. The company also adopts and leverages disruptive technologies in the manufacturing process
Learning and Growth Perspective	**i) Implement IT Suite:** The company has a well-managed ERP-IT solutions to cover its business operations and maintain customer and vendor management **ii) Roll out lean training:** The company has lean philosophy to achieve operational and manufacturing excellence. It implements pioneering practices of organizing and conducting in-house training on lean practices and TPM **iii) Improve internal communication:** The company has well planned mechanism to integrate with human workforce through robust communication channels, especially adopting digital practices

Objectives:

i) Financial perspectives

The company has the following financial objectives:

- To focus on market share and index
- To enhance the domestic and global market value chain
- To invest on product and process innovation
- To invest and strengthen on IT-enabled system
- To invest on infrastructure facilities
- To invest on technology and solutions

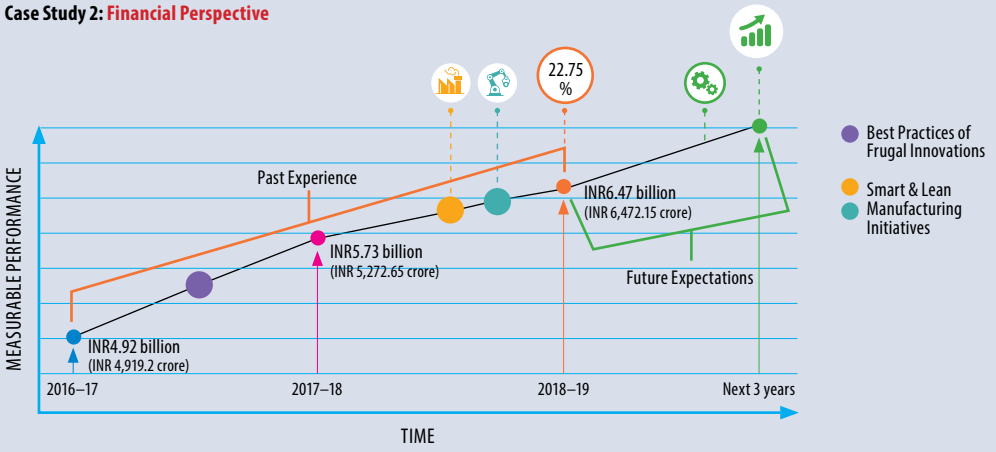
Outcomes/success of financial objectives

- The company is progressively growing, highlighted in the last three financial years (see Figures 3.17 and 3.18)
- Registered a business growth of 22.75% with a value of INR6,472.15 million
- The company's past performance is due to continuous innovations in product development, adoption of best practices of smart manufacturing ecosystem, and better customer service

- The company is expected to grow in similar lines in future with enhanced profit due to involvement of more disruptive technologies of Industry 4.0. Enhanced IT support system also strengthens the internal communication and customer service

FIGURE 3.17

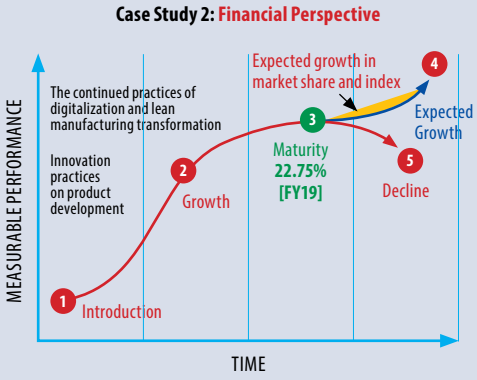
FINANCIAL PERSPECTIVE IN FY17–19



Source: Annual Report

FIGURE 3.18

GENERAL FINANCIAL PERSPECTIVES



ii) Nonfinancial perspectives (internal process perspectives)

The growth factors in the past (see Figure 3.19) are as following:

- Continuous innovation in product development
- Adoption of digitized manufacturing transformations

- Following the principles of lean philosophy and a completely agile value chain
- TPM in the manufacturing processes
- Total Employee Involvement in the organization
- Strong IT-ERP-enabled system
- Strength among the peers

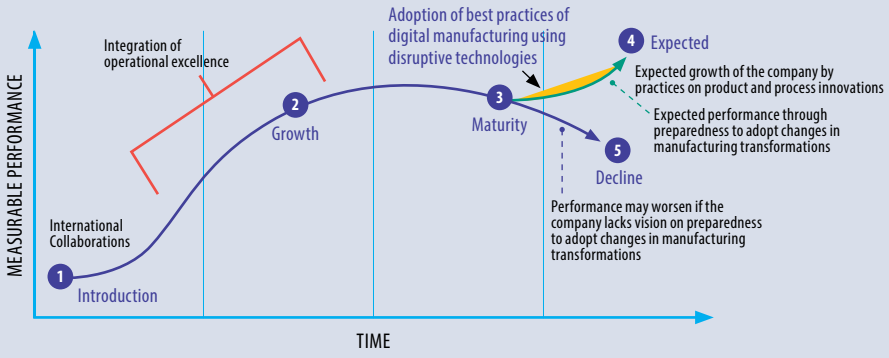
The future expectations of the company performance (see Figure 3.19) are highlighted as following:

- If the company follows its past experience and learns from past mistakes, it is expected to have enormous growth and be able to be one of the market leaders
- Expected to further optimize the process by economizing the manufacturing competitiveness
- The company must be in the forefront in adding values to the innovations of its products and maintain product quality
- As in the past, the company must value the customer, supplier, and partnership value chain
- Maintain to have a stronghold on domestic and global value chain
- Empower its human resource and continue to strengthen talent development

FIGURE 3.19

GENERAL NONFINANCIAL PERSPECTIVES

Case Study 2: Nonfinancial Perspective: Internal Process Perspectives



The factors that may decline the performance of the company (see Figure 3.19):

- Failure to leapfrog on new-age technologies
- Unready and not open to accept changes occurring in the manufacturing transformation

- Unprepared to equip the talent development to innovate the products, not being adaptive to digital manufacturing transformation, failure to increase the manufacturing efficiency and product quality
- Lack of vision to meet customer satisfaction and needs
- Unpreparedness to be the leaders in domestic and global value chain

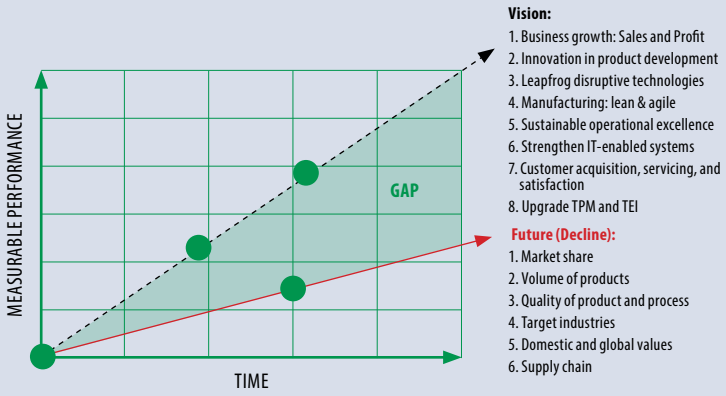
Step 4 (gap analysis)

Case Study 2

- **Potential (Vision):** The company has a strong vision for growth both in terms of sales (revenue) and profit. It aims to innovate product development and add to the product value chain. There are also plans to work on the cost effectiveness in the product and utilization of process automation. The objectives of the company are to leapfrog on disruptive technologies of Industry 4.0 and make the manufacturing process agile and lean. Plans are made to achieve sustainable operational excellence through its lean philosophy. The company realizes the importance of IT-ERP system and has further strengthened the system. It also has the vision to upgrade the TPM and Total Employee Involvement by adapting the best practices of manufacturing transformation strategies of Industry 4.0 (see Figure 3.20).

FIGURE 3.20

GAP ANALYSIS



- **Performance (Where will the company head to if it does nothing):** The company will lose its market share if it doesn't have a strong vision outlined as part of its strategies. The company will lag behind in volume and quality of the products. Target industries and customers may be lost which are the strengths of the company. This may lead to a decline in domestic and global market value chain. The lack of vision may hurt the supply chain as well (see Figure 3.20)

Case Study 3

Key performance indicators

i) Adopting Industry 4.0 and its transformation technologies

- The company has committed to standardize the process of automation through adoption of Industry 4.0
- Aims to create employment opportunities and serve humanity by deploying Industry 4.0 in the manufacturing process
- Scale up the business and enter into new vertical markets by adopting Industry 4.0

ii) Benefits for the company in applying Industry 4.0 and manufacturing transformation

- The company successfully standardized the automation solutions through Industry 4.0
- The company has patented the manufacturing process of Industry 4.0 by employing disruptive technologies
- In addition to financial growth the company excels in technological advancements
- The company stands to be the market leaders by creating 'Silent Factory' in India through the adoption of Industry 4.0
- The company successfully empowers women workforce in the assembly line of manufacturing transformation of Industry 4.0
- The company delivers good socioeconomic product by considering the manufacturing transformation of Industry 4.0

TABLE 3.7

SUCCESSFUL PLANNED STRATEGIC OBJECTIVES FOR CASE STUDY 3

Information here is obtained from the company's annual report 2017–19.

Planned Strategic Objectives	Qualitative & Quantitative Data
Financial Perspective	**i) Grow sales:** The company has achieved a turnover of INR318.99 billion (INR31,899 crore), showing an increase of 18.5% in FY19 compared to FY18 **ii) Maximum profit:** The company successfully attained PAT of INR46.75 billion (INR4,675 crore), showing an increase of 14.9% **iii) Manage investments:** The company has invested in cutting-edge technologies and solutions to design and develop innovative socioeconomic products according to the needs of the market and customers. The company also invested on various new markets and categories, and on international brands to captivate the global market value chain
Customer Perspective	**i) Improve brand awareness in Europe:** The company, through its joint collaboration with motorcycle brand in Europe, will create an awareness of the brand and will promote its global value chain **ii) Enter midmarket segment in Europe:** COMPANY C has entered into the European market by having a joint collaboration with UK brand Triumph to develop mid-cap-based motorcycles. The company has planned to open a design center in the UK as well **iii) Build strong relationship with top customers:** The company through its innovative business strategies and product solutions is able to attract and have strong hold on customers (Business to Customers/B2C)

Planned Strategic Objectives	Qualitative & Quantitative Data
Internal Process Perspective	**i) Market intelligence:** Indian automotive industry is fourth on the global platform, and is expected to raise a notch higher in 2021. About USD31 billion is spent on global engineering and R&D, with India accounting for 40%. A point to note is 8% of India's expenditure falls in the domain of automotive industry. COMPANY C is the third largest manufacturer of automotive products and solutions in the world and second largest in India **ii) Optimize the process in the plant:** The company has successfully standardized its automation solutions so that it can develop products economically and ergonomically **iii) Innovate and integrate products:** The company has built-in R&D set up to innovate and design socioeconomic products. The company has the practice of inviting ideas and concepts through academia-industry interface thereby building the competitive range of quality products and delivering solutions to the customers' needs and requirements
Learning & Growth Perspective	**i) Implement IT Suite:** The company has successfully invested on new age technologies, such as artificial intelligence and machine learning, areas of optical character recognition system, natural language process and voice recognition system for customer service and acquisition **ii) Roll out lean training:** The company conducts in-house trainings on TPM and to enhance the skill sets of its human workforce. The company also empowers women workforce in shop floor assembly lines on smart manufacturing process **iii) Improve internal communication:** The company has well managed channels to connect with the employees to have day-to-day correspondences through IT-supported system

Objectives:

Case Study 3

i) Financial perspectives

The company has the following financial objectives:

- To focus on business growth in terms of sales and profit
- To invest on technologies and solutions
- To invest on upskill and reskill for talent development
- To invest on technologies to enhance customer satisfaction

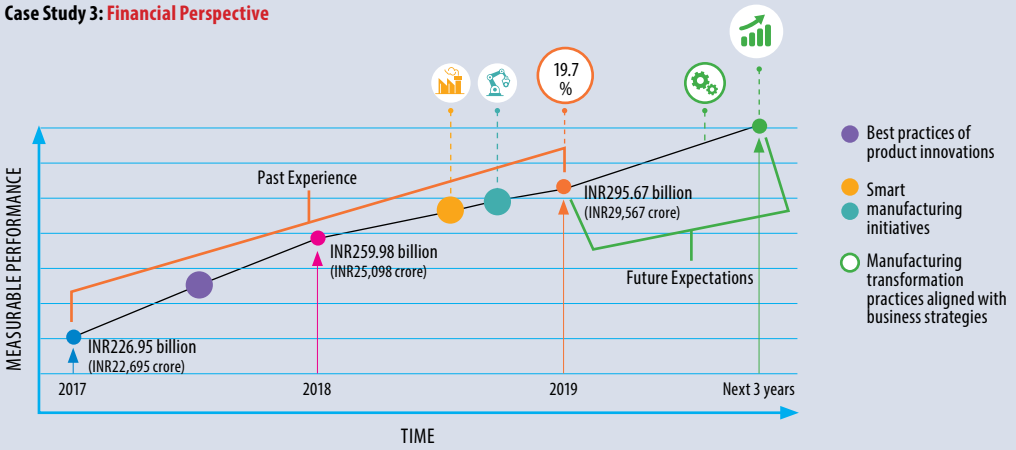
Outcomes/success of financial objectives

Analysis
Step 1

- Total domestic sales of all motorcycles grew by 7.8%, or 13.6 million units (FY19)
- Sales figure increased by 28.7% to over 2.5 million units (FY19)
- Share in the domestic motorcycle market increased by 3%, making it a total of 18.7%
- Business strategies are aligned to investing in new-age technologies and solutions to develop good socioeconomic products that meet market and customer demands and requirements

FIGURE 3.21

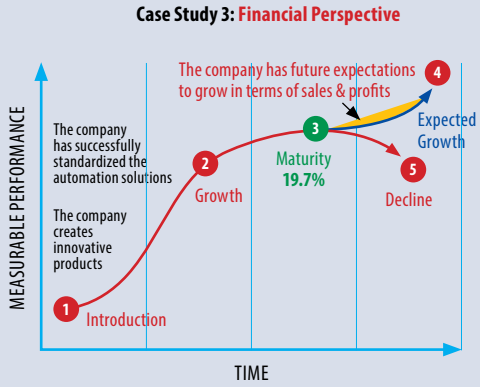
FINANCIAL PERSPECTIVE OF IN FY17–19



Source: Annual Report

FIGURE 3.22

GENERAL FINANCIAL PERSPECTIVES



Step 2

- The company has achieved a sizeable sales and profit margin, based on FY17–19 results (see Figure 3.22)
- Past performances demonstrate the strength of the company to grow and will continue to grow in terms of financial perspective due to its innovative business strategies (see Figure 3.22)
- Continuing to perform in similar fashion (like investment of technologies and solutions) will make the company achieve a bigger growth in future sales and profit
- Well-planned and robust business strategies that are aligned to investments on disruptive technologies and leveraging on essential technologies of Industry 4.0

- Empowering women workforce in the assembly lines of the workshop as part of its best practices

- Growth enablers for the present performance of the company is its R&D, collaboration with academia, and adoption of smart manufacturing transformation technologies of Industry 4.0. (see Figure 3.22)

- Expected to perform in similar lines if the company adopts and has robust mechanism to put into practice innovations, and technological advancements, enhances its product quality, continues to upskill and reskill the manpower, continues to serve the customer, and strengthens its partnership and value chain (domestic and global) (see Figure 3.22)

- Factors that may affect the performance (decline) of the company include lack of execution of quality tools and solutions of Industry 4.0 and failure to innovate its products to meet the demands of the market. Decline may also be experienced if it does not train and skill its workforce in accordance to the technological advancements in Industry 4.0. The other factors that may hurt the performance of the company is by not meeting product quality and failing to value and strengthen customer relationship (see Figure 3.22)

Step 3

- Manufacturing throughput increased due to the adoption of new-age disruptive technologies of Industry 4.0

- The company follows the 6R principles - Reuse, Redesign, Reengineering, Recycle, Recover, and Regulate - for sustainable manufacturing solutions thereby achieving less wastage

- Productivity, cycle time, and delivery speed are enhanced significantly due to the manufacturing transformation from conventional technologies to disruptive technologies of Industry 4.0. The company's strength lies in the optimum utilization of the resources and increased labor efficiency due to trained human workforce of Industry 4.0

- The company has the best practices of TPM that led to the growth of the organization both financially and technologically

- Company share grew by 3% to 18.7% in FY19 as a resut of its competitiveness, continuous innovations, and timely delivery of products and solutions to the customers

- Expected to grow in similar lines with initiatives in product innovations, process standardization, and integrated digitalized support system with customer service to meet the demands of the customers. Hence this will eventually lead to the growth, technologically and financially

ii) Nonfinancial perspectives (internal process perspectives)

The company has designed an internal process perspective in terms of its customers' needs and satisfaction. The following are the planned objectives:

- To become the market leaders in the automotive industry

- To be the people's brand in terms of customer service and satisfaction

- To optimize the process of manufacturing to obtain product quality and increase productivity
- To invest on latest technologies to develop competitive products

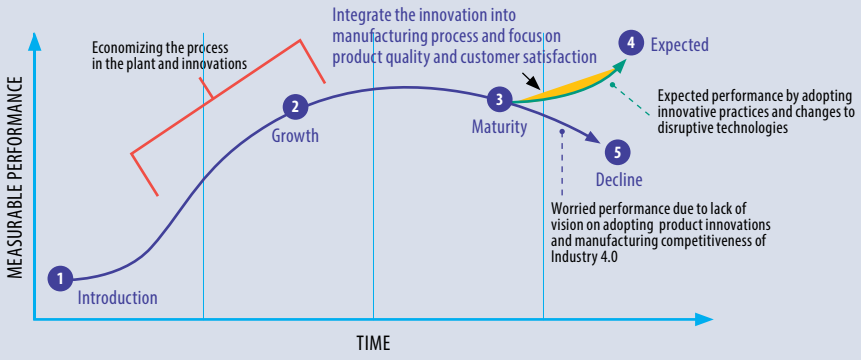
Outcomes of the planned objectives (Interpretation from the figure):

- The company is the third largest motorcycle manufacturer in India and contributes to the national and societal growth
- Growth is increased by the openness to accept the changes in manufacturing transformation and adapting to the changes by implementing the best practices of digital transformation in the manufacturing process (see Figure 3.23)
- Performing well in the past three financial years (FY17–19) (see Figure 3.23)
- Good record in performance arising from continuous innovations in product development, adoption of disruptive manufacturing technologies, enhancement in product quality, serving the customers according to their expectations, strengthened partnerships, and collaboration with suppliers and vendors
- Expected to perform well and grow further if it continues with its growth philosophy and by adapting the changes in the industry, including in product innovations, process manufacturing, product quality, technological supporting system to customer service, robust feedback system to meet customer satisfaction, valuing partnerships with suppliers, and good domestic and global chain. In fact the total ownership must be agile (see Figure 3.23)
- Decline may happen should the company slip back in any combination of factors, such as lack of innovation, technological advancement, talent development, supply chain partnership, market competitiveness, aligned business strategies with sustainable manufacturing solutions, robust system to support the customers, and most importantly lack of vision on product, process, and system quality (see Figure 3.23)

FIGURE 3.23

GENERAL NONFINANCIAL PERSPECTIVES

Case Study 3: Nonfinancial Perspective: Internal Process Perspectives



Step 4 (gap analysis)

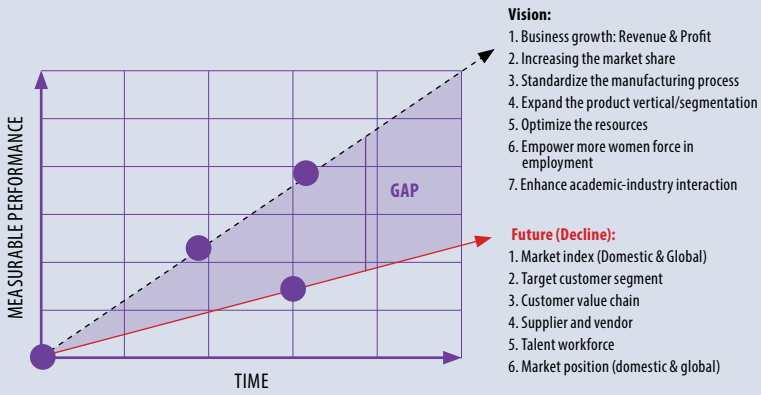
Case Study 3

- **Potential (Vision):** The company has strengthened its vision to grow in the automotive sector by sales (revenue) and profit. The company already practices standardization of automation solutions and plans to further add and strengthen the same. The company is prepared to changes occurring in the new-age technologies of Industry 4.0, including by studying and working on the gaps that may affect performance. Thus a robust mechanism has been strategized to enter into new segmentation as to be the front-runner of technological drivers (such as electric vehicle products). The company has further strengthened its customer service by adding digitalized support system. It also has plans to focus more on product quality, optimize resources, and work on academia-industry interactions (see Figure 3.24)

- **Performance (Where will the company head to if it does nothing):** Without the above vision, the company's performance may suffer in terms of sales (revenue) and profit. It may lose the market index as well as its customer value chain due to lack in target product segmentation and quality. The supplier and vendor management too will be affected. The company stands to lose its position in the domestic and global value chain (see Figure 3.24)

FIGURE 3.24

GAP ANALYSIS



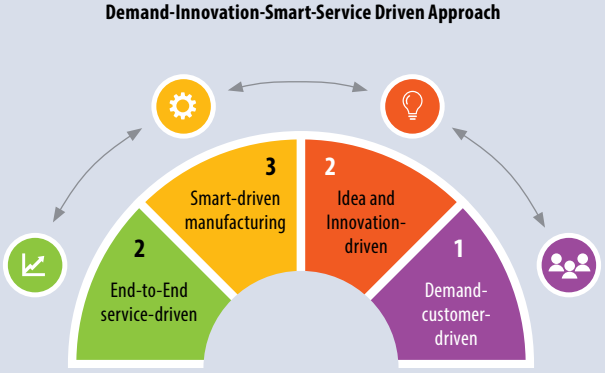
ANALYSIS OF CASE STUDIES

Analysis of Case Study 1: Manufacturer of Metal Components

The basic business functions and economic model of the company is shown in Figure 3.25.

FIGURE 3.25

BUSINESS AND ECONOMIC MODEL



A. Economic Alignment

S.No.	Parameter	Response	Description
1.	What are the economic and industry environments and how does the company strengthens the alignment with the market demand (including customer communication channel)?	As far as global trends in the casting industry are concerned, metal-casting is one of the most significant sectors and domains in the manufacturing industry economy. The industry is worth USD33 billion that directly or indirectly provides nearly 200,000 jobs in the USA alone, with many more added in Canada and Mexico. There is high push in the diversified sectors of industries (innovation-driven environment). India stands as the second largest castings manufacturer in the world.	In order to strengthen the alignment with the market demand, COMPANY A has mainly focused on improving the infrastructure by establishing world-class manufacturing facility, the Advanced Manufacturing & Technology Centre that houses the latest current technologies with the most advanced equipment. It is a competitive, comprehensive manufacturing world-class facility.
2.	Does the company have a clear idea which market trends are likely to have the greatest impact on the company over the next three years?	Yes, the company has a vast idea of the market trends.	The company has monitored, studied, and analyzed a multitude of current and future market trends particularly those with the greatest impact on the company in the upcoming three years. The technologies that the company mainly invested in are modern manufacturing and designing tools, such as 3D scanning, 3D measurement instruments along with 3D printing. This is in addition to the introduction of robotics and automation in the manufacturing cycle, balanced automation, and up-scaling of IT and application of light-weight and specially alloyed metal castings for reduced energy consumption. COMPANY A has positioned itself ideally in this scenario and is equipped with the new-age technologies and advanced manufacturing techniques and quality tools in the manufacturing systems.

S.No.	Parameter	Response	Description
3.	Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?	Yes, the company has a well-planned economic business model.	Increasing top line (turnover and profit) and the bottom line (PAT) of the last two years (FY19 and FY18) are clear evidence that the company has a robust economic model that quantifies and qualified how the manufacturing transformation initiatives and priorities impact their sales, revenue, and costs.
4.	Are they maximizing their use of remote diagnostics and other forms of direct feedback to improve the customer experience with their products and services?	Yes, the company is using its customers' feedback through a strong feedback communication channel and work force to improve the customer satisfaction and experience with its products and service.	NA

B. Technology Utilization

S.No.	Parameter	Response	Description
1.	What is the core technology innovation or adoption for manufacturing transformation and how those technologies are connected to their business function?	COMPANY A is using robot-assisted manufacturing, virtual tooling, rapid prototyping, and 3D printing for their product development.	The core technologies are connected to the main and business functions. Core business functions include production while secondary business functions include the facilitation of R&D and HR.
2.	Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?	Yes, it extends beyond the traditional R&D by addressing the entire ecosystem - transformation through digitalization.	Through utilization of digital technologies, the company transitions into a digital enterprise.

C. Talent Development

S.No.	Parameter	Response	Description
1.	Are there any skill gaps for manufacturing at different levels of employees or managers?	The company does not have any skill gaps for manufacturing at different levels of employees.	NA
2.	How does the company respond to the needs of human resources and talent development?	The company responds actively to the needs of talent development in human resources.	i) Internal & external training programs ii) Seminars iii) Cross-functional trainings & skill development initiatives iv) Regular interactions v) Online training programs
3.	Does the company have an effective HR strategy for recruiting, training, and retaining the talents needed for ongoing service transformation?	Yes, the company adheres to policies for recruitment, training, and retaining ongoing manufacturing transformation.	The company visits campuses for placements and actively participates in job fairs.

D. Supply Chain and Partnership

S.No.	Parameter	Response	Description
1.	Are there any complexities or challenges caused by distributed sourcing, engineering, and production?	The company has a strong supply chain collaboration and partnership.	NA
2.	How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?	It manages well with diverse partners in terms of quality, compliance, and risks.	**i) Quality:** Adopting best practices of Industry 4.0, focus on latest technologies, world-class equipment, and standardization of process. **ii) Risk:** Maintains strategy, operational, and financial risks. **iii) Compliance:** With Securities and Exchange Board of India's (SEBI) listings and provision of listing regulations.

S.No.	Parameter	Response	Description
3.	Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?	Yes, the company is aware of such coordination.	The company has business strategies focused on innovation, collaboration, and support from the government, partnership with an international organization that results in producing quality products, and address the challenges of market trends.
4.	Does the company have in place robust methods for coordinating strategy and planning through the organization and partner ecosystem?	Yes, the company has in place robust methods for facilitating the partner ecosystem.	NA

E. Market Competitiveness

S.No.	Parameter	Response	Description
1.	What are the identified competitive advantages in domestic and global market?	**i) Domestic market:** Make in India, Digital India **ii) International market:** Collaboration with UK's most renowned castings research institution - Castings Technology International (CTI).	**International:** Cost effective suppliers, products manufactured in world-class manufacturing facility in India (Advanced Manufacturing and Technology Centre), and low labor cost in India.
2.	What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?	The company has technology and inherent business strengths, addresses its weaknesses, well aware of the threats, and meets the objectives and aims of opportunities.	i) Quality in innovation of product development ii) Putting into practice of smart systems for manufacturing iii) Quality in product and talent development
3.	How does the company deal with competitors for a sustainable business model?	The company deals with the competitors with smart approaches.	Investing in infrastructure, R&D, and latest technologies as well as collaboration with the government of India and international institutes.
4.	Does the company embrace a design, build, and service of any philosophy, and how do they compare to competitors' capabilities and customer expectations?	Yes, the industry embraces a design, build, and service in all business operations (domestic and international market).	The company creates and establishes world-class capabilities in manufacturing, has a strong commitment to quality, and reduction in overall cost.

F. Innovation Ecosystem

S.No.	Parameter	Response	Description
1.	Are there any external sources (from the government, academia, or industry) supporting the company's business ideas' generations and innovations?	Yes, they have external sources from the government of India and partners with academic institutions.	The company receives funding from the government.
2.	What is the mechanism of the strategic alliance as an innovation ecosystem and how the company collaborates with the ecosystem and benefit from the ecosystem?	**Mechanism:** Funding/grants from the government for product innovation and development.	**Collaboration on product development:** Ministry of Science & Technology, Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises. **Benefits:** Product development and commercialization for different industrial applications.

G. Strategic Management

S.No.	Parameter	Response	Description
1.	Does the company have any strategies?	To increase the sales and revenue (domestic and global), invest in infrastructural facilities to improve products and process development, and increase customer satisfaction through a variety of products. Also provide quality-centric work culture for employees.	Well-defined business strategies aligned with manufacturing.
2.	What is the past performance over time in terms of its objectives?	The industry has increased its revenue, increased customer relationship, and enhanced the skills of the employee.	Robust performance in terms of domestic and global value chain.
3.	Why the performance over time in the past?	The company's vision on products and process innovation, and attract customers through state-of-the-art and world-class quality products. Skills of employees are improved through in-house training and online training programs. The company has implemented well-managed customer management system and IT solution to increase and strengthen customer relationship.	i) Quality and diversified product innovation ii) Practice of smart transformation strategies iii) Trained talent development iv) Sustainable manufacturing operational excellence
4.	What is the anticipated performance in the expected period of future (e.g., next three years)?	The company expects a higher growth rate in the coming years as they have strong technology for innovation and increased global revenue.	The company has reduced costs while ramping up capacity utilization. This will boost the EBITDA (earnings before interest, taxes, depreciation, and amortization) which the company expects to gradually improve from 16% in FY19 to 20% in FY22E. The company has forecasted an EBITDA of INR474 million for FY22E at 20% EBITDA growth margin.
5.	How does the company try to achieve its objectives of performance in the future?	Through implementation of the latest technologies in Industry 4.0 and adopting best approach and practices.	Strong implementation of manufacturing transformation strategies of Industry 4.0.
6.	What are the driving forces or resources that drive the performance and how are they managed?	Establishment of world-class manufacturing facilities, strength in research and innovation, international collaborations, support from the government.	Creating world-class facility in smart manufacturing, more collaborative projects with different agencies.
7.	What are the disadvantageous factors hurting performance and how they can be managed?	Lack of innovations, non-implementation of Industry 4.0, no usage of quality tools for monitoring, non-execution of quality training to reskill and upskill the human workforce.	Lack of quality in innovation, process and product development, and talent development.

H. Regulation of Operations

S.No.	Parameter	Response	Description
1.	Are there any rising standards from environmental concerns or standards-based factors like ISO compliance that apply across an increasingly interconnected world?	Yes, India has implemented environment and climate change laws (2020) and regulations, including the environmental policy.	The company is aware of the rules and regulation of rising standards of environment process and ISO compliance.
2.	What are the impacts to the company and how are the issues resolved?	The impacts are green and sustainable approach toward its manufacturing and operations.	Adoption of sustainable practices through new advanced manufacturing technologies, resulting in standardized process.

Framework for Analyzing the Results of Business Strategies

Step 1: Evaluation based on Balanced Scorecard strategy map for diverse performance indicators

Parameter	Qualitative Study
Financial perspective	• To invest in technological innovation • To invest on building a world-class manufacturing facility • To increase revenue (sales) and profit • To invest in digital technologies as to increase customer base and strengthen customer service and relationship
Customer perspective	Well planned as to focus on enhancing and improving customer support experience and communication.
Internal process perspective	The company continuously works on the innovation and product development through world-class manufacturing facility. To maintain and accelerate technological leadership.
Learning and growth perspective	**i) IT:** Implementation of software to support customer management **ii) Lean training:** The company has adopted the best practices and provide training to employees in areas of advanced technologies and manufacturing **iii) Culture:** Culture of empowerment and promoting women workforce. Employee-friendly work practices

Step 2: Evaluation based on strategy dynamics for quantified performance over time

S.No.	Parameter	Descriptive Study
1.	What is the past performance over time in terms of company's objectives?	50% growth in FY19 compared to FY18.
2.	Why is performance following its past/current path?	Investment in world-class infrastructure manufacturing facility.
3.	Where will performance go if we continue as we are doing today?	The performance of the company in the last year demonstrates the robustness of its business strategy and the consistency of its practices and execution. COMPANY A delivered its highest revenue during the period of FY19, and expects for business growth to maintain sustainability as capacity rises and newer disruptive new-age technologies comes into operation.
4.	What are the driving forces or resources that drive the performance and how they are managed?	Continuous technology upgrade, strong customer feedback mechanism, experienced staff who are qualified and well trained as well as effective promoters, and remarkable presence in the export (global value chain) and domestic markets are the main forces that will drive the performance of company in the future.
5.	What are the disadvantageous factors hurting performance and how they can be managed?	i) Innovations lacking in quality in product development, non-implementation of Industry 4.0, and lack of quality in product and talent development ii) No focus on customer service and satisfaction iii) Additionally, the changing regulatory requirements as to incorporate them into the company's business strategy, the convergence of risk, compliance, processes and control mechanisms, economic slowdown that may affect and cause decline in performance

Step 3: Evaluation based on qualitative factors and improved performance

S.No.	Parameter	Qualitative Description
1.	Quality-related factors	**i) Product performance:** High performance products in metal castings **ii) Waste utilization:** Reengineering, redesigning, and recycling (Zero Defect-Zero Effect mechanism)
2.	Time-related factors	**Process throughput/Deliveries/Productivity/Labor efficiency:** Utilization of robot-assisted manufacturing, rapid prototyping increasing productivity and overall efficiency of manufacturing process, and timely delivery of products.
3.	Flexibility-related factors	**i) Manufacturing effectiveness:** Lean manufacturing and smart manufacturing technologies in process and product development **ii) Resources utilization:** Initiatives on resource utilization (green policy) **iii) New product introduction:** The company has introduced various new products in casting **iv) Product innovation:** Advanced manufacturing facility augments new product innovations

S.No.	Parameter	Qualitative Description
4.	Finance-related factors	**i) Cash flow:** Surplus cash and cash equivalents as on FY19 as well as increase in cash flow compared to FY18. The cash flow also depicts a robustness in 2019 at INR321.742 million (INR3217.42 lakh) as compared to INR162.796 million (INR1627.96 lakh) in 2018. Further, capital expenditure has decreased from INR265.740 million (INR2657.40 lakh) in 2018 to INR177.432 million (INR1774.32 lakh) in 2019 which strengthens working capital funds of the company. The increase in cash flow is also due to improvements in operating cycle and collection times **ii) Sales/Profitability:** Growth in sales (domestic + global) led to enormous profit
5.	Customer satisfaction-related factors	**i) Market share:** Top gainer in BSE index **ii) Customer service:** Through customer relationship management and implementation of ICT technologies for customer management
6.	Human resource-related factors	**i) Employee involvement:** Employees are involved in new technologies through advanced training programs. Additionally, the establishment of its advanced manufacturing facility increased job openings **ii) Employee skills/learning:** Trained through online learning, seminars, and in-house training programs **iii) Quality of work-life:** Well-balanced work culture

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The company has a clear vision of creating innovations in product development, putting into practice smart manufacturing transformations, ensuring quality in product development to deliver good socioeconomic products, and to reskill and upskill its workers as part of talent development. Its vision is to strengthen the financial perspectives (sales and profit). Should the company not strengthen its business and growth due to lack of vision in product innovations, non-implementation of manufacturing transformation of Industry 4.0, and with no focus on quality products, it will head toward decline. Additionally, if the company does not focus on strengthening its customer service and satisfaction, it may affect performance.

FIGURE 3.26

INNOVATION-DRIVEN MANUFACTURING OUTCOMES OF CASE STUDY 1

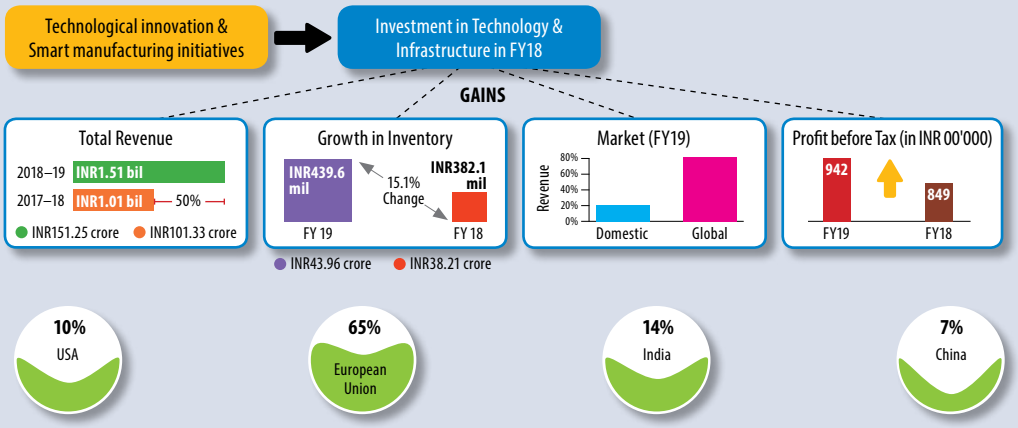
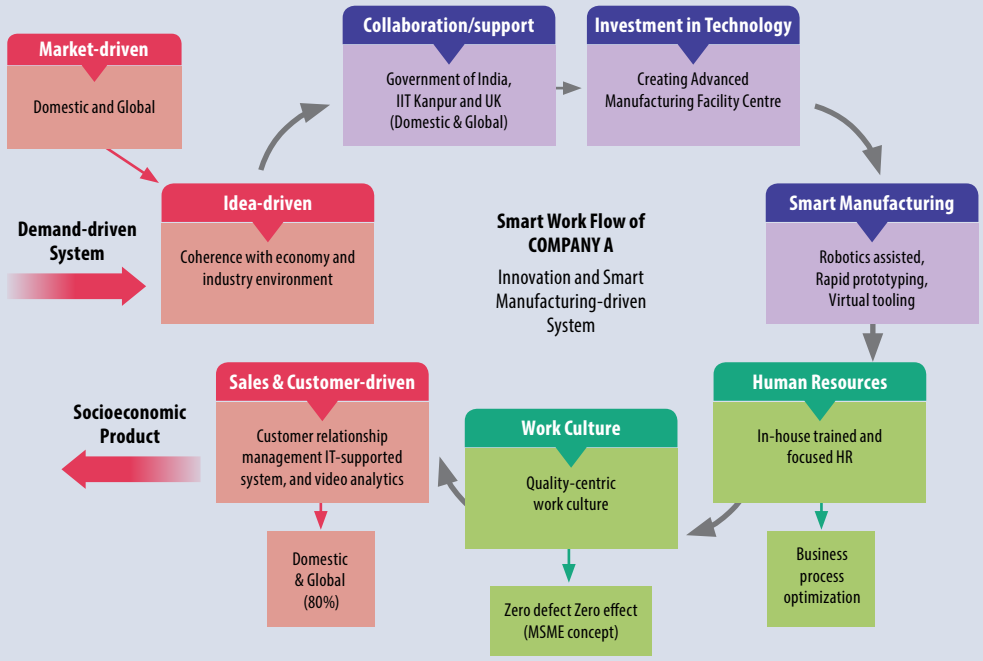


FIGURE 3.27

SMART WORKFLOW AND APPROACH OF CASE STUDY 1



Analysis of Case Study 2: Gear Manufacturer

A. Economic Alignment

S.No.	Parameter	Response	Description
1.	What are the economic and industry environments and how does the company strengthens the alignment with the market demand (including customer communication channel)?	The product (gears) finds most application in the automobile industry and there is a great demand for it.	The company aligns through continuous product innovations and establishing manufacturing facilities.
2.	Does the company have a clear idea which market trends are likely to have the greatest impact on the company over the next three years?	The company has strong outlook on the prevailing and future trends of the market.	The company has the clear vision on market trends.
3.	Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?	The company has well-defined economic model to meet the demand and supply of the product through strong value chain.	The company has strong business and economic model to achieve growth.
4.	Are they maximizing their use of remote diagnostics and other forms of direct feedback to improve the customer experience with their products and services?	The company utilizes an efficient IT-based system and online web-based system to connect to its customers.	The company has a well-supported digital system to satisfy customer needs and demands.

B. Technology Utilization

S.No.	Parameter	Response	Description
1.	What is the core technology innovation or adoption for manufacturing transformation and how those technologies are connected to their business function?	The company utilizes IoT and autonomous robotics system.	The core technologies are connected to the main and supporting business functions. Core business functions include production while secondary business functions include the facilitation and upgrading of research through R&D.
2.	Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?	Yes, it extends beyond the traditional and conventional R&D through strategic national and international collaborations to address the entire ecosystem - transformation through digitalization.	Through utilization of digital technologies, the company transitions into a digital enterprise.

C. Talent Development

S.No.	Parameter	Response	Description
1.	Are there any skill gaps for manufacturing at different levels of employees or managers?	The company does not have any skill gaps for manufacturing at different levels of employees.	The company has strong policies for training and upgrading the skills of the human workforce.
2.	How does the company respond to the needs of human resources and talent development?	The company responds actively to the needs of talent development in human resources.	TPM training implemented.
3.	Does the company have an effective HR strategy for recruiting, training, and retaining the talents needed for ongoing service transformation?	Yes, the company adheres to policies for recruitment, training, and retaining ongoing manufacturing transformation.	The company visits campuses for placements and actively participates in job fairs.

D. Supply Chain and Partnership

S.No.	Parameter	Response	Description
1.	Are there any complexities or challenges caused by distributed sourcing, engineering, and production?	The company has a strong vendor management and source for manufacturing.	No challenges arise from the complexity or challenges of distributed sourcing, engineering, and production.
2.	How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?	The company manages various diverse partners through well-defined quality system practices.	The company adopts TPM, Total Employee Involvement (TEI), and most importantly, lean-based system.
3.	Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?	Yes, the company is aware of such coordination.	The company has a well-managed and well-planned business strategy that are coordinated with its multiple business functions thus remarkably contributing to the market trends.
4.	Does the company have in place robust methods for coordinating strategy and planning through the organization and partner ecosystem?	The company has the best, robust system for the coordination.	The company's strength is its robust business strategy and dynamic strategic planning through the support of organizations and business partners' ecosystem. This makes the complete value chain more agile and lean.

E. Market Competitiveness

S.No.	Parameter	Response	Description
1.	What are the identified competitive advantages in domestic and global market?	The benefits of the government of India's initiative 'Make in India' are the promotion of product development and marketing. International collaboration also facilitates the growth of the organization.	The company's strength lies in strong implementation of national government policies and initiatives, and aligning with global policies to be at the forefront of the market.
2.	What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?	The company has a strong hold on product innovation and implementing the best practices of smart manufacturing techniques. As far as opportunities are concerned, the market potential for its products is huge.	More product innovations, strong implementation of quality tools, delivering good socioeconomic product, well-planned talent development, and finally, strong customer service and satisfaction.

S.No.	Parameter	Response	Description
3.	How does the company deal with competitors for a sustainable business model?	The company deals with the competitors through continuous innovations and quality product developments.	The company invests on product development and collaborates with international partners. The company also implements Industry 4.0 technologies, reskilling and upskilling as part of talent development, and focused customer satisfaction.
4.	Does the company embrace a design, build, and service of any philosophy, and how do they compare to competitors' capabilities and customer expectations?	The company has presence across the nation and has a strong domestic and global market. Thus it has the best practices in serving its customers anytime, anywhere with strong policies.	The company has established state-of-the-art manufacturing facility in domestic and global locations. The company serves the customer in domestic and global value chain.

F. Innovation Ecosystem

S.No.	Parameter	Response	Description
1.	Are there any external sources (from the government, academia, or industry) supporting the company's business ideas' generations and innovations?	The company does not have any external sources for funding.	The company has the culture of encouraging the generation of business ideas from in-house employees as well as through international partnerships and collaborations.
2.	What is the mechanism of the strategic alliance as an innovation ecosystem and how the company collaborates with the ecosystem and benefit from the ecosystem?	The company has international collaboration with strategic partners to strengthen the innovation ecosystem and put into practice smart manufacturing technologies.	The company has domestic and global collaborations with industry partners which strengthens the ecosystem of innovations.

G. Strategic Management

S.No.	Parameter	Response
1.	Does the company have strategies?	To increase the profit (sales and revenue) through domestic and global market.
2.	What is the past performance over time in terms of its objectives?	The company for the last three years (FY17–19) has recorded a tremendous growth on sales, revenue, and profit.
3.	Why the performance over time in the past?	The reason is due to quality product innovation, utilization of modern smart technologies and strong IT support, quality policies for customer service, focus on domestic and global markets, and value the partners and collaborators in the supply chain.
4.	What is the anticipated performance in the expected period of future (e.g., next three years)?	The company expects a higher growth rate in the next years as they have strong policies in terms of technology for innovation and increased domestic and global revenue.
5.	How does the company try to achieve its objectives of performance in the future?	Through implementation of the latest technologies in Industry 4.0 and adopting best approach and practices, such as strengthening lean practices and focusing on employees' involvement. Most importantly, to be focused on customer service and satisfaction.
6.	What are the driving forces or resources that drive the performance and how are they managed?	The driving forces are due to quality in innovation, delivering good socioeconomic products, and focused implementation of a wider range of competitive products that satisfy diverse market segments. Enhanced customer service and satisfaction, a strong focus on talent development, and value supply chain with business partners' ecosystem. They are managed with well aligned business strategies.
7.	What are the disadvantageous factors hurting performance and how they can be managed?	Nonfocus on quality innovation, lack of policies to upgrade the manufacturing ecosystems, nonfocus on talent development, and lack of quality products may hurt the performance. The company's growth may decline if policies and business strategies are not aligned.

H. Regulation of Operation

S.No.	Parameter	Response	Description
1.	Are there any rising standards from environmental concerns or standards-based factors like ISO compliance that apply across an increasingly interconnected world?	Yes, India has implemented environment and climate change laws (2020) and regulations, including the environmental policy.	The company thoroughly understands the economic environment standards and quality regulations and policies.
2.	What are the impacts to the company and how are the issues resolved?	The company strongly believes in the green philosophy of manufacturing.	The company adopts the best policies and practices to redesign, reuse, and recycle the waste materials.

Framework for Analyzing the Results of Business Strategies

Step 1: Evaluation based on Balanced Scorecard strategy map for diverse performance indicators

Parameter	Qualitative Study
Financial perspective	• To enhance sales and profit through aligned business economic model • To invest on quality innovations and establish green manufacturing facility • To invest on IT-enabled system in strengthening internal communications and customer service
Customer perspective	To enhance the customer relationship (B2B) domestically and globally.
Internal process perspective	The company strongly believes in product innovation and utilization of smart manufacturing technologies for manufacturing.
Learning and growth perspective	The company has strong IT-ERP system to support purchase and supply management as well as maintain customer relationship management. The company has 'operational excellence' policy both in manufacturing and training.

Step 2: Evaluation based on strategy dynamics for quantified performance over time

S.No.	Parameter	Descriptive Study
1.	What is the past performance over time in terms of company's objectives?	The company has a total turnover that registered an increased growth of 20.21%.
2.	Why is performance following its past/ current path?	The performance is due to a stronghold on product innovation and smart manufacturing technologies.
3.	Where will performance go if we continue as we are doing today?	As the performance for the last three years has been on the growth stage, the company is expected to grow at a faster rate as there will be a greater demand for automobile manufacturing.
4.	What are the driving forces or resources that drive the performance and how they are managed?	The driver for performance is lean philosophy (operational excellence).
5.	What are the disadvantageous factors hurting performance and how they can be managed?	The performance can be affected by lack of focus on quality innovations and non-implementation of best practices of Industry 4.0. Another factor is economic slowdown.

Step 3: Evaluation based on qualitative factors and improved performance

S.No.	Parameter	Qualitative Description
1.	Quality-related factors	**i) Product performance:** Performance of the products is higher as they find major applications in automotive industries **ii) Waste utilization:** Lean philosophy and green manufacturing (Redesign, recycle, and reuse) **iii) Innovation:** The company continuously adds a wider range of products through innovations
2.	Time-related factors	The product delivery is improved through reduction in lead time by utilizing innovative smart solutions.
3.	Flexibility-related factors	The company adopts lean manufacturing philosophy for manufacturing and utilizes latest technologies. Also, the company has built a sophisticated manufacturing facility embedded with new-age technologies.
4.	Finance-related factors	The company has surplus cash flow and continuously invests on building infrastructures and purchasing assets.
5.	Customer satisfaction-related factors	The company has a strong customer base both domestically and globally and they are connected through a digital system.
6.	Human resource-related factors	The company has in-house training facilities to train employees on TPM system.

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The company has identified the gaps between business and the market. The company has strong vision on quality innovation, developing good socioeconomic products, and focused implementation of smart manufacturing ecosystems. The company aims to reskill and upskill workers under talent development and technology utilization as well. Lack of the highlighted vision especially on product development, practices on smart manufacturing systems, and customer service may observe a decline, technologically and financially.

Analysis of Case Study 3: Motorcycle Manufacturer

A. Economic Alignment

S.No.	Parameter	Response
1.	What are the economic and industry environments and how does the company strengthens the alignment with the market demand (including customer communication channel)?	The automobile industry is on the growth stage and is expected to grow further at a faster rate.
2.	Does the company have a clear idea which market trends are likely to have the greatest impact on the company over the next three years?	Yes, the company has a clear outlook on the growth market trends. The company is starting its manufacturing operation of 2-wheeler segment where the market potential is huge.
3.	Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?	The company has well-defined economic models of their products, based on the demand of customers and the market.
4.	Are they maximizing their use of remote diagnostics and other forms of direct feedback to improve the customer experience with their products and services?	Yes, they are using remote diagnostics, such as mobile apps, service centers, web-based interfaces, dealer showrooms, and call centers. The company also conducts regular surveys with dealers, brokers, retailers, and roadside mechanics to strengthen and improve its business model.

B. Technology Utilization

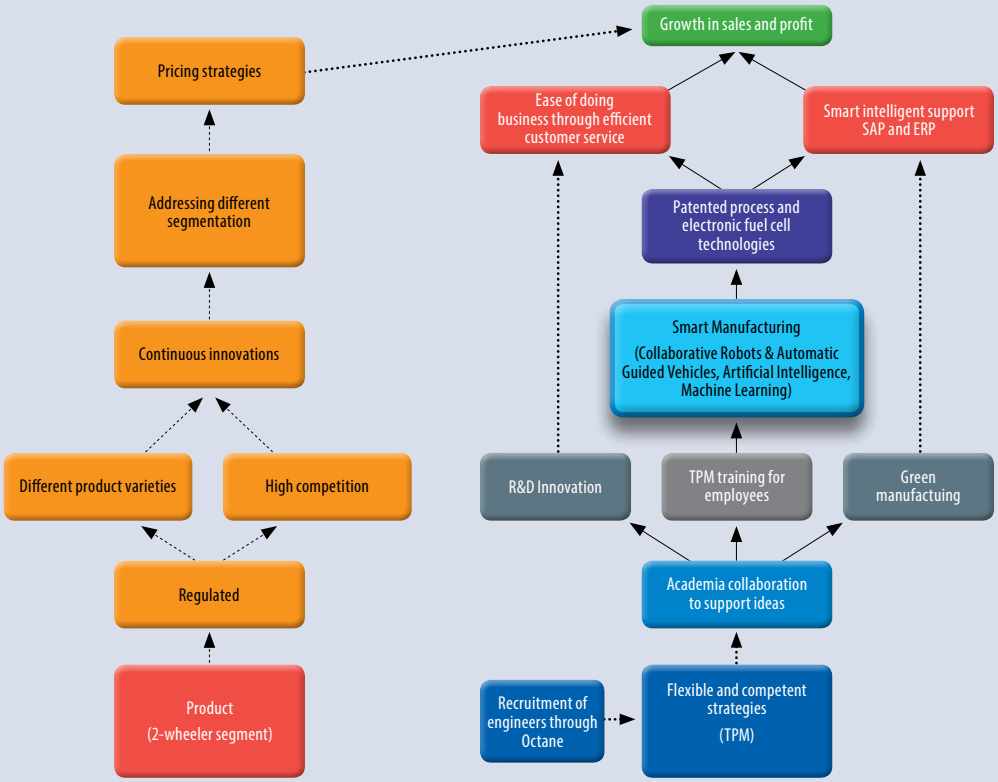
S.No.	Parameter	Response	Description
1.	What is the core technology innovation or adoption for manufacturing transformation and how those technologies are connected to their business function?	The core technology innovation for manufacturing transformation utilizes collaborative robots and autonomous guided vehicles in the assembly lines. **Outcomes:** Low payback period, zero annual maintenance costs.	The other technologies are machine learning, AI, and optical character recognition.
2.	Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?	Yes, it extends beyond the traditional R&D by addressing the entire ecosystem - transformation through digitalization.	Patented material handling - decal application.

C. Talent Development

S.No.	Parameter	Response
1.	Are there any skill gaps for manufacturing at different levels of employees or managers?	The company has no manufacturing skill gaps at different levels of employees and/or managers. The company addresses the challenges by effective training systems.
2.	How does the company respond to the needs of human resources and talent development?	The company organizes training programs to increase productivity. The employees are given training through TPM pillars (safety, health, and environment).
3.	Does the company have an effective HR strategy for recruiting, training, and retaining the talents needed for ongoing service transformation?	Yes, the company has effective HR strategy. i) To recruit through flagship internship program 'Octane' ii) To train young engineers through 'Graduate Trainee Engineering' (flying start) iii) The company partners with a foreign university to provide opportunities for employees to pursue higher education

FIGURE 3.28

WORKFLOW AND TECHNOLOGY-DRIVEN MANUFACTURING SYSTEM AND OUTCOMES OF CASE STUDY 3



D. Supply Chain Collaboration and Partnership

S.No.	Parameter	Response
1.	Are there any complexities or challenges caused by distributed sourcing, engineering, and production?	They have strong supply chain collaborations and partnerships throughout India dealership network (both urban and rural).
2.	How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?	The company manages diverse partners by implementing various policies, such as TPM, compliance standards, and risk management policy.
3.	Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?	Yes, the company is aware of its business function by adopting best practices of manufacturing and supply.
4.	Does the company have in place robust methods for coordinating strategy and planning through the organization and partner ecosystem?	Yes, the company has in place robust methods for facilitating the partner ecosystem. It also has strong dealership network.

E. Market Competitiveness

S.No.	Parameter	Response	Description
1.	What are the identified competitive advantages in domestic and global market?	**i) Domestic market:** Make in India and Digital India **ii) International market:** Collaboration with KTH Holding	Strong implementors of national government policies.
2.	What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?	The company has its strength of strong branding, unique marketing strategy, and continuous innovations.	Strong product innovation, focused quality on product, implementation of Industry 4.0, and focused customer service.
3.	How does the company deal with competitors for a sustainable business model?	The company deals with its competitors through indigenous innovations in products and processes.	First to implement Cobots technology in India's automotive sector in 2010. It uses 150 Cobots in the manufacturing facility, where the Cobots work alongside human workforce. Nearly 50% of the employee who uses Cobots are women workforce.
4.	Does the company embrace a design, build, and service of any philosophy, and how do they compare to competitors' capabilities and customer expectations?	The company has a strong dealership and customer network across India. They connect to end users through digitalized platforms.	The company has a strong service-based value chain in domestic and global value chain.

F. Innovation Ecosystem

S.No.	Parameter	Response
1.	Are there any external sources (from the government, academia, or industry) supporting the company's business ideas' generations and innovations?	The company has in-house R&D that collaborates with academic institutions.
2.	What is the mechanism of the strategic alliance as an innovation ecosystem and how the company collaborates with the ecosystem and benefit from the ecosystem?	This company established collaborations with the academia and venture capitalists to support innovation. The company plans to establish design centers in several parts of the international domain.

G. Strategic Management

S.No.	Parameter	Response
1.	Does the company have strategies?	The company primarily focuses on niche product development. Its objectives are investing in advanced manufacturing technologies for smart production and equipping human resources with quality training programs.
2.	What is the past performance over time in terms of its objectives?	• Well-styled, appealing products, and astute pricing • Growth in domestic market share • Increase in domestic sale of motorcycles • Increase in market share
3.	Why the performance over time in the past?	The reason is through smart product development and smart manufacturing transformation initiatives.
4.	What is the anticipated performance in the expected period of future (e.g., next three years)?	The company is expected to grow at a higher rate to become the leader in 2-wheeler segment (scooter and motorcycle).
5.	How does the company try to achieve its objectives of performance in the future?	The company plans to achieve the target through continuous innovation in product development.
6.	What are the driving forces or resources that drive the performance and how are they managed?	Company's lean manufacturing strategies (increase efficiency and reduce defect in parts per million (PPM)), exports, and expansion to premium bikes.
7.	What are the disadvantageous factors hurting performance and how they can be managed?	The factors that affect performance are labor issues and economic downturn.

H. Regulation of Operation

S.No.	Parameter	Response
1.	Are there any rising standards from environmental concerns or standards-based factors like ISO compliance that apply across an increasingly interconnected world?	Yes, India has implemented the environment and climate change laws (2020) and regulations, including the environmental policy.
2.	What are the impacts to the company and how are the issues resolved?	Green approach toward its operation: • Green technology • Alternate fuel • Wind power • Green manufacturing • 6R principles: Reduce, Reuse, Recycle, Recover, Redesign, Regulate

Framework for Analyzing the Results of Business Strategies

Step 1: Evaluation based on Balanced Scorecard strategy map for diverse performance indicators

Parameter	Qualitative Study	Quantitative Study
Financial perspective	i) The company has the financial objective to increase its sales turnover ii) There are plans to invest in the latest technologies of smart manufacturing and smart product development iii) The company aims to invest in training and development of skilled human workforce	i) The company turnover increased by 18.5% to INR318.99 billion (INR31,899 crore) ii) The company's three-wheeler segment grew by more than 22% (43% growth by exports)
Customer perspective	**Segmentation:** The company develops products according to age, gender, income group, region, family size, social class, price sensitivity, loyalty, expectations, personality attributes, and lifestyle differentiation. They also focus on targeting niche vehicles like electric vehicle category.	Quality products for different segments.
Internal process perspective	i) Restructure and realignment in the organization: product harmonization, marketing synergies, customer focus, and corporate alignment facilitating 'one stakeholder, one message' ii) Internal financial controls for facilitating design, implementation, and maintenance embedded with internal reviews that occur periodically to review the operational effectiveness and sustenance iii) Smart innovation in products and entering into the electric vehicle segments. Patenting the process with the use of Industry 4.0 technologies (Cobots)	The company has focused internal process perspectives to address market challenges, optimize the process performance, and continuous product innovations.
Learning and growth perspective	**i) IT:** Implementation of SAP to meet core business needs and to handle both distribution and inventory management. Cloud-based system with complete dealer management system as well as sales and distribution management **ii) Lean Training:** The company has, as part of its best practices, provide employee training in the areas of TPM and Kaizen **iii) Culture:** Culture of empowerment and promoting women workforce. Employee friendly work practices	The company has 4,800 employees who are trained through 311 training programs that spans 7,900 man-days. Over and above this, employees were given training through TPM pillars, which included Safety, Health, and Environment-related trainings that span 5,319 man-days.

Step 2: Evaluation based on strategy dynamics for quantified performance over time

S.No.	Parameter	Descriptive Study
1.	What is the past performance over time in terms of company's objectives?	The company reported increase in sales (2-wheeler segment), improved product realization, better profitability, and higher export growth.
2.	Why is performance following its past/ current path?	Through increase in productivity by the utilization of automation process. Also, the employees are trained through TPM and self-driven learning system.
3.	Where will performance go if we continue as we are doing today?	The performance is expected to grow at a higher rate because of the demand for their products.

S.No.	Parameter	Descriptive Study
4.	What are the driving forces or resources that drive the performance and how they are managed?	Lean and green manufacturing. Additionally, the use of collaborative technologies in production increased the productivity and throughput time.
5.	What are the disadvantageous factors hurting performance and how they can be managed?	High competition in 2-wheeler segment. They can be controlled by the introduction of latest-technology vehicles that incorporates IoT and data analytics.

Step 3: Evaluation based on qualitative factors and improved performance

S.No.	Parameter	Description	Responses
1.	Quality-related factors	**i) Product performance:** High performance products in motorbike ranges (especially sports model) **ii) Waste utilization:** 6R principles: Reduce, Reuse, Recycle, Recover, Redesign, Regulate **iii) Innovation:** Innovation in fuel cell technology and engines	
2.	Time-related factors	**Process throughput/deliveries/productivity/labor efficiency:** Use of Cobots and autonomous guided vehicles increases productivity and high-quality output. Also, the use of automated process, such as automated guided vehicles in manufacturing assembly lines increases overall efficiency and product deliverables. Increased flexibility and reliability in production.	507 vehicles per person per year (V/P/Y) to 804 vehicles per person per year, which is a 58.5% increase YoY.
3.	Flexibility-related factors	**i) Manufacturing effectiveness:** Lean manufacturing, smart technologies in process, and product development **ii) Resources utilization:** Initiatives on resource utilization (green policy) **iii) New product introduction:** The company has introduced 2-wheeler electric vehicle **iv) Product innovation:** Electronic fuel cell technologies, Advanced technology engines for low fuel efficiency and pickup	The company has recyclability and recoverability rates of 87% and 94%, respectively. Kaizen for resource conservation have led to reduction of 8.18% overall in power and 16.53% in fuel consumption. Also, packaging material consumption reduced in FY2018–19: plastic - 5.24 ton, corrugated material - 86 ton, and wood - 680 ton **Products:** Chetak (Electric vehicle) DTS-i, design and programming of clutch actuation robotic arm.
4.	Finance-related factors	**i) Cash flow:** The company has surplus cash and cash equivalents as of FY19 **ii) Sales/Profitability:** Growth in sales in 2-wheeler segment that led to enormous growth profile of the company **iii) Cost control:** 30% to 40% reduction in cost, zero maintenance cost, reduction in power consumption due to utilization of cobots, and low payback period **iv) Productivity:** Use of Cobots increases productivity	The company sales and profit are enormously increased due to its aligned business strategy with manufacturing systems.
5.	Customer satisfaction-related factors	**Customer service:** Chatbot customers in the website, portal, mobile app, and wallet. COMPANY C has deployed multiple self-service options on the interactive voice responses for proactive updates under customer service and satisfaction. The company also addresses non-digitally savvy customers by having introduced a "missed call service" to enable customers to obtain details of their latest relationships and servicing.	i) Chatbot ii) Digital voice recognition systems iii) Usage of digital technologies for improved customer servicing
6.	Human resource-related factors	**i) Employee involvement:** Employed more than 50% women workforce to work with Cobots. Involvement of employees, including women workforce in collaborative technologies **ii) Employee skills/learning:** Continuous employee training in TPM programs **iii) Quality of work life:** Social welfare centers to improve the quality of employees work- life	**i) Work force:** The company has 358 women working in manufacturing plants and engineering **ii) Skills/Learning:** In 2018–19, more than 4,800 employees were trained through 311 training programs, spanning 7,900 man-days. Over and above this, employees were given training in TPM pillars, which included Safety, Health and Environment-related training, spanning 5,319 man-days

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The company has a strong vision in improving its domestic and global value chain. The vision is to be realized through quality product innovation, best practices of smart manufacturing, and reskilling the employees as part of talent development. If the company derails from its vision, it may decline in growth of sales and profit. Not adopting strong business economic model which is aligned with manufacturing practices may hurt the performance of the company.

CONCLUSION

The government of India has taken several ubiquitous initiatives and measures in inculcating the value of self-reliance through its mission policy 'ATMANIRBHAR BHARAT' (Self-Reliant India Mission). The aim of the policy is to be 'vocal for our local products' and take them to the global platform. The focus is on economy, infrastructure, systems, vibrant demography, and demand. The self-reliant India will improve the development of indigenous technologies of Industry 4.0. Adopting Industry 4.0 technologies will further enhance the manufacturing ecosystem competitiveness in the country. These technologies will empower India to achieve its vision. The mission is implemented in different phases that encompass business (including MSME), agriculture, new horizons of growth, and government reforms and enablers. The Indian Brand Equity Foundation (IBEF) reports that the government has targeted for well-defined ambitious figure to increase the manufacturing output to 25% of GDP in 2025 from 16% in 2014. IoT plays a major role in India's Industry 4.0. There is a huge market potential for IoT in the country due to its strength in IT. In the next five years, it is estimated to capture 20% of the global market share. In order to achieve this ambitious target, the government has introduced initiatives such as 'Green corridors'. Start-up India policy contributes to the growth of several sectors that include IoT product innovations and digital solutions.

Major Key Findings and Implications from Case Studies

Case Study 1: Manufacturer of Metal Components

i) Industry level

The Indian foundry industry is the world's second largest and has the production capacity of 12 million ton of metal cast components with a turnover of USD19 billion. The foundry casting industry in expected to have an estimated growth of 13%–15% CAGR in the upcoming years due to the demands of engineering industries, such as manufacturing and construction.

ii) Enterprise level

- This company has finally achieved a smart growth over the years by investing in smart manufacturing infrastructures and redefined the manufacturing process by continuous innovations

- Similarly, it has also invested on knowledge and collaborated with the government of India for smart innovations, emerging as the largest innovator in the casting industry in the country

- The company had a total capacity of 1,800 ton before setting up its advanced manufacturing facility in India, achieving a revenue figure of INR950 million–1 billion (INR95–100 crores) in FY18 [5]
- After establishing the advanced manufacturing facility, COMPANY A quadrupled its capacity
- Business revenue grew by 50% (FY19) in spite of the increase in manufacturing expenses and inventory rise by 66% and 15%, respectively
- Additionally, its global value chain also increased with the advent and implementation of smart manufacturing facility
- Enhanced the quality of product development by implementing Industry 4.0's manufacturing transformation strategies
- The company adopted the best practices of smart manufacturing technologies, such as digital system to provide added value to customer relationship
- The long-term vision is to grow by continuously innovating technologies and implementing manufacturing transformation strategies of Industry 4.0
- The company commits to adhere to the national policies, such as 'Make in India', 'Digital India', and 'Innovate India'

iii) Entrepreneurial system

- The company has the entrepreneurship spirit in its business strategies
- Plans to foster the entrepreneurial ecosystem
- Adopts the entrepreneurial corporate culture
- This company's entrepreneurial ecosystem transforms the company into a world-class technologically advanced company in metal casting components

Case Study 2: Gear Manufacturer

i) Industry level

Gears are considered primarily as the significant component and part of the automotive system. The growth of the gear market is proportionally related directly to the sales of automotive vehicles and is expected to have a growth of 5.5% CAGR in 2020–25. Other potential applications for gears are the wind and solar power systems which see an increasing demand as well. Asia-Pacific leads in the gear global market and has the largest demand for automotive gear market. The challenges in the automotive gear market are the advent and entry of electric vehicle segment in the market which may hinder the growth of gear market.

ii) Enterprise level

- The company has strong focus on frugal innovations and embracing new-age disruptive technologies of smart manufacturing, such as IoT and robotics assembly
- Strong commitment toward implementation of lean manufacturing, TPM, and total employee involvement that add value to the complete value chain
- Registered a turnover business growth of 20.28% in FY19 compared to FY18
- Export income as of FY19 stood at INR1.912 billion, accounting for an increase of 46.06% as compared to FY18. These outcomes show strong hold on global value chain
- The company continues to focus on creating competitive range of quality products and solutions through smart innovations and adopting manufacturing transformation strategies of Industry 4.0. This enables building strong customer and stakeholder relationship
- Committed plans are made to grow the company by implementing Industry 4.0 technologies and the company has also established a separate segment to contribute for the robotics systems
- The company designs, develops, and manufactures products in accordance with the government policies, such as 'Digital India', 'Startup India', and 'Make in India'

iii) Entrepreneurial system

- The company has the spirit of entrepreneurship that is propelled to excel in the growth of business and technology
- Adopted the practice of entrepreneurship by seizing business opportunities in the domestic and global market

Case Study 3: Motorcycle Manufacturer

i) Industry level

India is the fourth largest automobile market in the world, with the automobile industry set to continue to grow, owing to the great demands of the business-to-customer (B2C) segment and is expected to achieve a figure of INR16.16–INR18.18 trillion by 2026.

ii) Enterprise level

- The company has embraced and leveraged on new-age technologies for business growth and has added value to the quality of its products and process innovation

- Standardized the manufacturing process through automation solutions like Cobots and autonomous guided vehicles (AGVs) in the assembly lines

- Reported a 30%–40% reduction in cost and 58% increase in productivity by implementing smart manufacturing transformation strategies, such as Cobots and AGVs in the manufacturing process

- Registered an increase in business revenue by 18.5% and operating income grew by 20.1% in FY19

- By implementing smart manufacturing practices, the company is able to achieve high quality products and innovate its processes, including by patenting the technological process using smart manufacturing technologies

- Invested in cutting-edge digital technology to serve and strengthen customer relationship

- The company is the forerunner in holding the global value chain through export initiatives

- This company is a pioneer in the automotive segment and aims to grow by entering into new technology innovation and focusing on implementing the manufacturing transformation strategies

Lessons Learned and Implications to Other Industries

The case studies have provided a good insight and overlapping benefits when companies embrace Industry 4.0 technologies and transformations. Some of the specific lessons learned as well as the implications are:

- Research studies clearly demonstrate the proven benefits of adopting the best practices of Industry 4.0's manufacturing transformation strategies. A benchmark is set for other companies to adopt the essential technologies of Industry 4.0 in product and process innovations

- The culture of innovation and entrepreneurship fosters business and technological growth of the organization

- Companies must align its business strategies with sustainable manufacturing model and adopt digitalized system in the manufacturing process, such as lean, TPM, and total employee involvement

- A road map can be drawn for other companies to invest in advanced manufacturing facility as well as to promote the domestic and global value chain that lead to significant gains

- A blueprint is provided where product innovation and manufacturing process are aligned with national policies

- The importance of collaboration with the government and international partnership foster the complete value chain
- Product quality and value of customer relationships are vital

TABLE 3.8

MSME DEFINITIONS FROM THE INDIAN ENTREPRENEUR PERSPECTIVE [6]

Composite Criteria for Classifications of the Indian MSME			
Major Classification	**Micro Enterprises (India)**	**Small Enterprises (India)**	**Medium Enterprises (India)**
Services in terms of manufacturing enterprises and MSME's offering/ rendering services to the society (based on investment in Plant and Machinery or Equipment and annual turnover)	• Investment in Plant and Machinery or Equipment is NOT MORE THAN INR10 MILLION (INR1 CRORE) • Annual turnover NOT MORE THAN INR50 MILLION (INR5 CRORE)	• Investment in Plant and Machinery or Equipment is NOT MORE THAN INR100 MILLION (INR10 CRORE) • Annual turnover NOT MORE THAN INR500 MILLION (INR50 CRORE)	• Investment in Plant and Machinery or Equipment is NOT MORE THAN INR500 MILLION (INR50 CRORE) • Annual turnover NOT MORE THAN INR2.5 BILLION (INR250 CRORE)

RECOMMENDATIONS

Based on the three case studies, the recommendations are:

- To leapfrog on new-age disruptive technologies
- To enhance government-industry-academia interactions to implement Industry 4.0
- To establish more experience zones and demo centers of Industry 4.0
- To promote vocational education and research on Industry 4.0

CHAPTER 4

JAPAN

INTRODUCTION ON INDUSTRY 4.0 APPLICATION AND CONTEXT CONDITIONS

Manufacturing Industry in Japan

Manufacturing is the second most important sector to Japan's economy. The industry now trails after the service industry and accounts for 22% of the nominal GDP in 2019. The last three decades have thrown various unexpected difficulties to 217,601 Japanese manufacturers. In the early 1990s, the collapse of the "bubble economy" brought Japan one of the most serious depressions caused by overinvestment in real estate. In 2009, a worldwide financial crisis "Lehman shock" ruined manufacturers, followed by a big earthquake in east Japan in 2011. Figure 4.1 shows the short-term economic survey by the Bank of Japan [1].

FIGURE 4.1

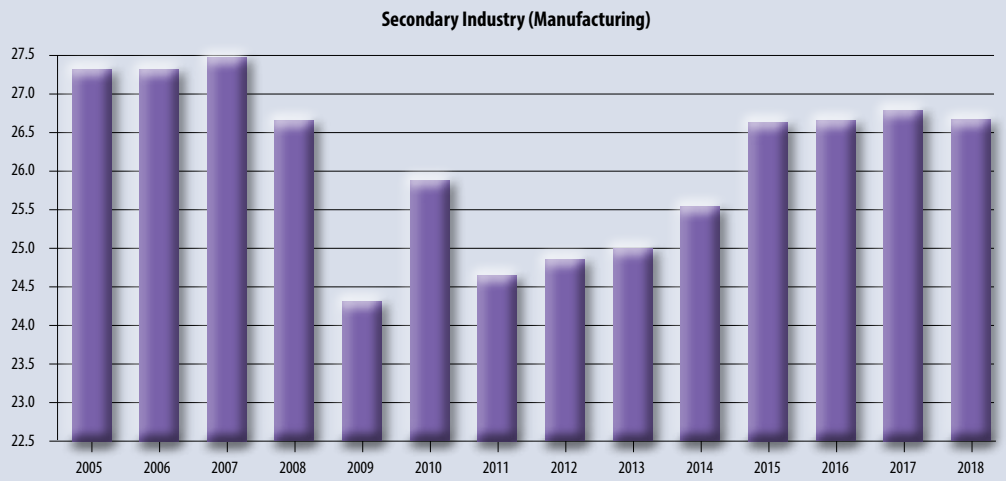
TIME SERIES OF THE ECONOMIC DIFFUSION INDEX

Even during such tough periods, manufacturers were still key players in the Japanese economy. Proportion of the manufacturers (including construction) in GDP temporally decreased to approximately 24%, but it has been leveling out by around 26.5% in 2018.

Shifting production bases to foreign countries caused the decline of presence of manufacturers in the GDP ratio but, as important innovation creators, manufacturers are impacting the Japanese enterprises.

FIGURE 4.2

GDP PROPORTION OF THE SECONDARY INDUSTRY IN JAPAN [2]



The global market share of Japan-made manufactured products has been decreasing due to severe market competition but material manufacturers took advantage of the quality level and technology. The Ministry of Economy, Trade, and Industry (METI) compared the size of enterprises and its market share with other regions on 1,214 products. This survey indicates that Japanese enterprises have a bigger market share in material industries.

TABLE 4.1

SALES VOLUME AND MARKET SHARE IN 1,214 PRODUCTS [2]

	Japan	USA	Europe	PR China
< USD12 billion	23	30	20	27
< 60% market share	256	123	46	61

One of the typical industries that explains this situation with clarity is the mobile phone. The global market share of Japanese mobile phone manufacturers was 1.2% in 2016 (6.7% in 2012). However, Japanese phone parts and material suppliers remained the same at 15.3% since 2012.

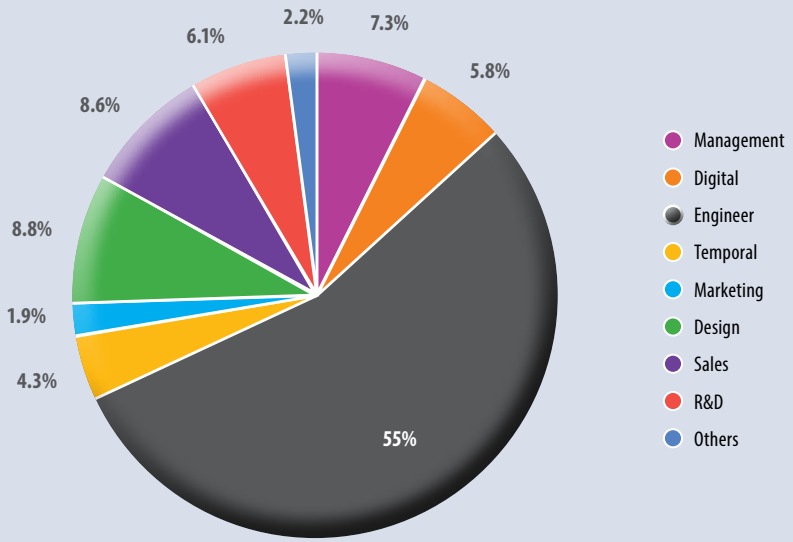
Due to severe competition with other regions, Japanese manufacturers had no choice but to shift their production bases to other countries in the past decades. But now they are facing tough competition when it comes to advanced technology, high labor cost, and various local

risks caused by political and macroeconomic reasons. As a result, some manufacturers have shifted back to their domestic production.

On the other hand, centralizing the production has brought another risk to the manufacturers' supply chain. Frequent natural disasters, like typhoons and earthquakes, have forced manufacturers to shut down production and change delivery routes. Shortage of manpower is another serious issue. The Japanese population has the world's biggest super-aging society where 28.4% of the Japanese population is over 65 years old in 2019. The figure is still increasing and is estimated to be 31.1% in 2030. This has a cascading impact in economic sectors. According to a research by METI in 2018, 94.8% of manufacturers faced shortage in manpower, especially for skilled engineers and seriously affected daily operations. METI's research highlighted that the number one reason for quality issues is the lack of employee training. This shows manufacturers face a shortage of in-house trainers who should transfer their skills to ground employees.

FIGURE 4.3

SHORTAGE OF MANPOWER IN JAPANESE ENTERPRISES (%) [2]

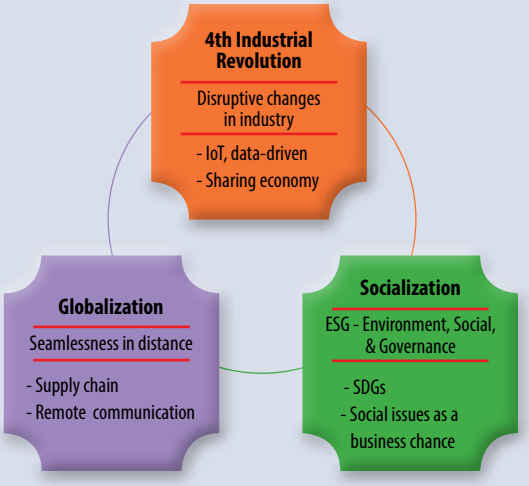


Manufacturing SMEs in the Wave of Industrialization

The biggest turning point for manufacturing small and middle-sized enterprises (SMEs) was the collapse of the "bubble economy" in the 1990s. SMEs made big efforts to decrease costs for their debt repayment. In the 2000s, after the economic recovery, SME players increased their production yield and made profit to clear up their negative legacies, such as debts or excess equipment. Following that period, SMEs have been in line with the trends of globalization, digitalization, and socialization. SMEs were also required to engage in higher and more complicated issues than they did in the past. Figure 4.4 indicates the three types of trends faced by the manufacturing SMEs.

FIGURE 4.4

THREE BIG TRENDS OF JAPAN'S MANUFACTURING SMES [2]



i) Fourth industrial revolution (Industry 4.0)

Totally new business models will be developed by utilizing latest digital technologies. SME manufacturers are required to adopt disruptive changes, such as Internet of Things (IoT), artificial intelligence (AI), sharing economy, and/or open innovation with external resources. The past industrial structure will be drastically changed by newcomers from different fields.

ii) Globalization

The SME manufacturers will need to manage their global supply chain, which means SMEs will have stakeholders outside of Japan. They also need to understand and analyze global market trends as well as be exposed to linguistic or cultural differences in business. The global business process has been transforming. A web conference system now enables anyone to make a real-time, face-to-face connection globally. Major languages are translated to Japanese by AI automatically.

iii) Socialization

SMEs should consider both profit making and problem solving toward environmental and social issues. Environment, social, and government (ESG) factors can be considered both as business risk and opportunity. They need to have a strategic viewpoint in solving social problems with their services or products.

Technological Innovation, Business Model, and Market Development

"The white paper on manufacturers 2019" emphasizes on data-driven business model. The number of manufacturers who collected data from their production process decreased from 66.6% in 2016

to 58.0% in 2018, despite the fact that more manufacturers utilize or will utilize the collected data for the purpose of improvement in a single production process (from 24.1% in 2016 to 32.8% in 2018) or in production lines (from 22.7% to 29.7%). This fact suggests that more production departments are getting the know-hows of data analysis. Proper data analysis visualizes detailed needs and challenges at the production frontline, which enables them to improve productivity in a timely and efficient manner. However, only a small number of manufacturers realize the use of effective communication with customers or marketing activities. There are only 6.8% of the manufacturers who utilize data for marketing activities or customer communication while 30% utilize them to visualize their operations.

Government-Academic-Industry Collaborations for Industry 4.0 in Manufacturing Sectors

There are two aspects in the government-academia-industry collaboration. One is "How are manufacturers empowered by their innovation creation?" The other is "How do manufacturers apply advanced technology to workplace transformation?" The Japanese government has been rolling out diverse programs to support these two aspects. This segment looks into the challenges the government identified in innovation creation and the counteractions to those challenges.

METI's research on "Industrial Technologies in the New Era" emphasized on the importance of open innovation. That means more Japanese manufacturers have collaborated with external organizations, although its percentage is still lower than the American and European manufacturers. With regards to the start-ups, the number of both university-originated ventures and the amount of venture capital toward seed-stage businesses are far lower than the USA. The number of patent applications and R&D expenses has been slightly decreasing.

The fluidity of human resources among government-industry-academia section is still low, though the number of R&D researchers has remained stable. Japan is the only country where the number of PhD decreased from 2008 to 2014. Based on these facts, the role of enterprises, universities, and public organizations are under redefinition. The below organizations are playing a role as an accelerator to bridge the stakeholders. These organizations support the empowerment of manufacturers' innovation creation in various ways.

i) New Energy and Industrial Technology Development Organization (NEDO)

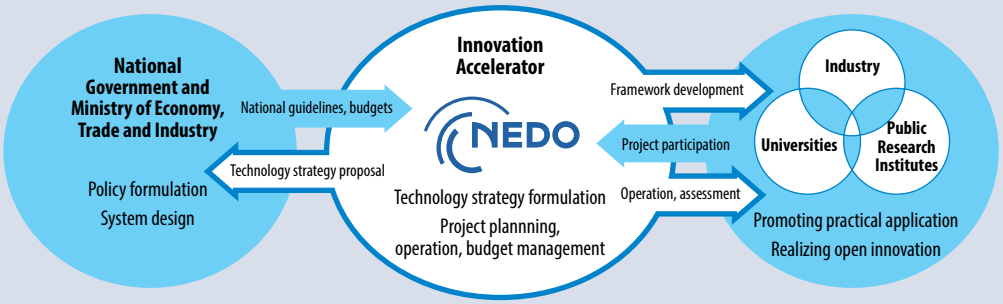
NEDO plays an important role in the Japanese economic and industrialization policies through its funding of technology development activities. NEDO also acts as an accelerator to realize two basic missions of addressing energy and global environmental problems, and enhancing industrial technology.

NEDO coordinates and integrates the technological capabilities and research abilities of the industry, academia, and government, instead of employing its own researchers. It also promotes the development of innovative and high-risk technologies. NEDO aims to contribute to the resolution of social issues and market creation by demonstrating and producing practical applications of such technologies.

The organization has an annual budget of about USD1.5 billion. It is used for the fields of energy system, energy saving & environment, industrial technology, and creation of new industries. NEDO's role is to plan, operate, and manage the budget of each project.

FIGURE 4.5

NEDO'S ROLE AS AN INNOVATION ACCELERATOR [3]



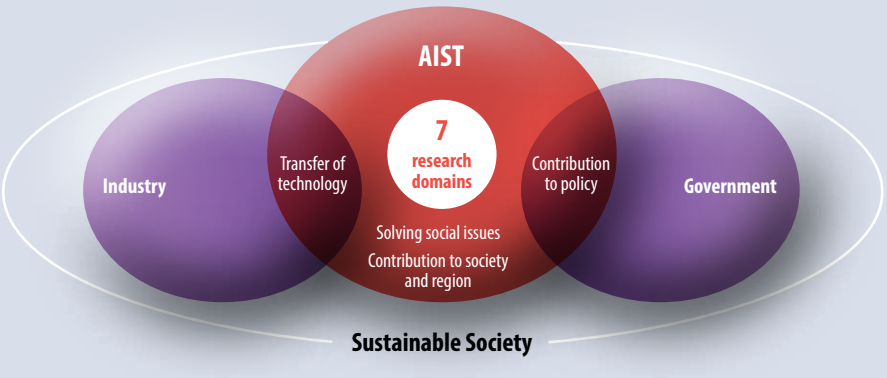
ii) National Institute of Advanced Industrial Science and Technology (AIST)

AIST is one of the largest public research organizations in Japan that focuses on the creation and practical realizations of technologies useful to the Japanese industry and society, and on bridging the gap between innovative technological seeds and commercialization. For this, AIST is organized into five departments and two centers that bring together core technologies to exert its comprehensive strength. Functioning differently from NEDO, AIST is a research institute in the fields of energy, life sciences, material, electronics, and IT.

As a core and pioneering existence of the national innovation system, AIST has about 2,300 researchers carrying out R&D works at 11 research centers across the country. They are focused on formulating national strategies while monitoring the changing environments of innovation.

FIGURE 4.6

STRUCTURE OF AIST AND ITS STAKEHOLDERS [4]



iii) Greater Tokyo Initiative

While NEDO and AIST specialize on the science and technology development at the national level, the Greater Tokyo Initiative is a general incorporated association that supports the growth of SMEs in and around the western region of Tokyo. This initiative consists of 252 enterprises, mainly of small manufacturers, 32 educational institutes (universities and technical colleges), 19 administrative bodies, eight banks, 65 regional chambers of commerce, and 114 registered experts in the region.

Going on the vision of "Connected Industries", the Greater Tokyo Initiative strives for the creation of new business opportunities by connecting regional resources of industry-academia-government finance. Their mission is to collaborate for continuous growth of regional SMEs who join in new businesses. They set two target values: 100 sustainable technical collaborations among members and 20% sales increase during 2018–20 compared to 2017. The past programs that achieved successful collaborations are shown in Table 4.2.

TABLE 4.2

OUTCOMES OF TECHNICAL COLLABORATION [5]

	2013	2014	2015	2016	Total
Collaborations, R&D support	392	303	262	386	1,343
Marketing and sales	2	0	7	3	12
Training and employment	549	608	1,184	127	2,468

This initiative functions as a platform for open innovation in the region. Based on the SMEs' unique technologies, the initiative facilitates business matching and collaborations between the SMEs with the academia and large enterprises. The initiative also provides hands-on support to SMEs when they install an IoT system in their workplace.

Beneficial Government Policies and Business Environment for Industry 4.0

In 1995, the government of Japan enacted the Basic Act on Science and Technology to roll out science and technology-related policies systematically and consistently. Under this act, the 5th Basic Plan was started in 2016 by the Council for Science, Technology, and Innovation (CSTI). CSTI is one of the four councils of important policies that are represented in the cabinet office. CSTI comprises the prime minister, relevant ministers, and experts. The CSTI investigates and discusses basic policies concerning science and technology, and budgets and allocation of human resources as well as assesses Japan's key R&D.

i) Basic policies on science and technology

- The Science and Technology Basic Plan
- Comprehensive Strategy on Science, Technology, and Innovation

ii) Allocation of the science and technology budget and human resources

- Policies for the Allocation of Resources, including the Science and Technology Budget
- Action Plan for the Implementation of Important Science and Technology Policy Measures

iii) Evaluation of nationally important R&D

- General Guidelines for Evaluating Government Funded R&D

iv) Other key issues surrounding the promotion of science and technology decision-making and coordination regarding such programs

- Cross-ministerial Strategic Innovation Promotion Program (SIP)
- Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT)
- Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST)
- Funding Program for Next Generation World-Leading Researchers (NEXT Program)
- New Low Carbon Technology Plan

The 5th Plan sets four main goals to achieve: (i) creation of future industry and social transformation, (ii) response to economic and social challenges, (iii) enhancement of basic science power, and (iv) structuring a circulation system of human resources, knowledge, and funding.

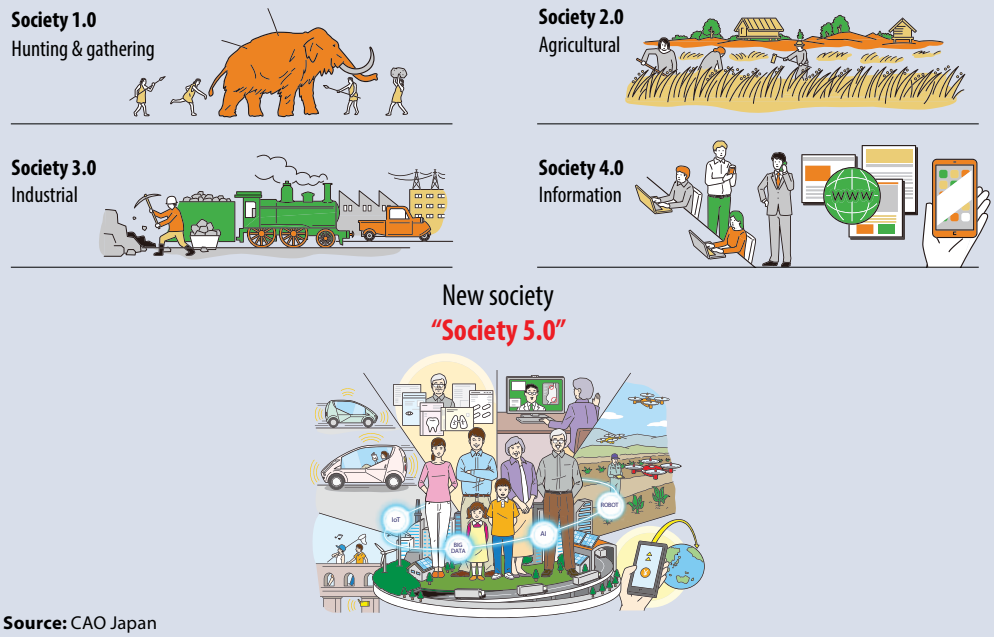
Balancing economic advancement with future industry and social transformation, the Japanese government created the "Society 5.0" slogan. This was proposed in the 5th Basic Plan as a future society that Japan should aspire to. It follows the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0).

Society 5.0 aims to achieve a high degree of convergence between cyberspace and physical space. In the past information society (Society 4.0), people would access a cloud service (databases) in cyberspace via the Internet and search for, retrieve, and analyze information or data. In Society 5.0, a huge amount of information from sensors in physical space is accumulated in cyberspace. In cyberspace, this big data is analyzed by AI, and the analysis results are fed back to humans in physical space in various forms.

In the face of such major changes in the world, new technologies, such as IoT, robotics, AI, and big data, all of which can affect the course of a society, are continuing to progress. Japan seeks to make Society 5.0 a reality as a new society that incorporates these new technologies in all industries and social activities, and achieve both economic development and solutions to social problems in parallel.

FIGURE 4.7

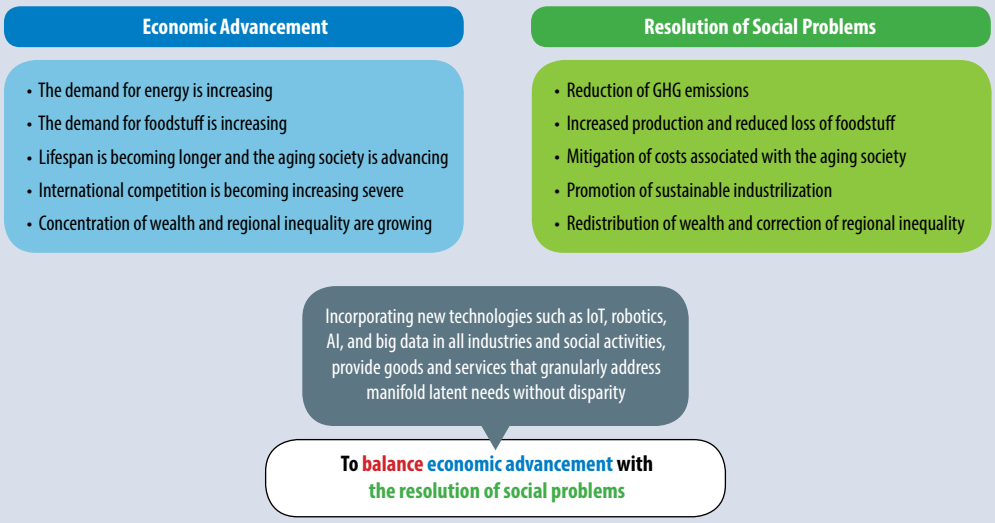
TRANSITION OF THE JAPANESE SOCIETY [6]



Source: CAO Japan

FIGURE 4.8

CONCEPT OF "SOCIETY 5.0" [6]



Compared to Industry 4.0 that focuses on the technological application in a factory, Society 5.0 looks at the betterment of the whole society with the advanced technologies. In this concept, advanced technologies are just one of the tools to achieve the highest goal, the betterment of people's life.

TABLE 4.3

COMPARISON OF "INDUSTRY 4.0" AND "SOCIETY 5.0" [7]

	Industry 4.0	Society 5.0
Beginning	2011–	2016–
Origin	Germany	Japan
Concept	"Smart factory"	"Supersmart society"
Goal	Factory automation with AI and IoT	Making our life system better with AI and IoT

In addition to the government-academia-industry collaborations, the Japanese government has prepared a variety of supporting schemes to boost the "Society 5.0" concept among manufacturers.

i) Funding for IT software installation [8]

METI periodically supports SMEs of all sectors when installing software in their workplace, though the scheme is not limited to manufacturers. A maximum of USD45,000 is subsidized to companies that plan to improve productivity by installing IT software. The subsidy supports to tackle challenges. For instance:

- Example 1 - Installing robotic process automation (RPA) to minimize burdens of administrative works
- Example 2 - Installing a groupware to share project information remotely with team members
- Example 3 - Installing an AI chatbot to reduce burdens of a customer center

ii) Funding for high-skill education to Society 5.0 [9]

The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) raises a Society 5.0-specific funding scheme for high-skilled human resource development. The objective of this scheme is to secure skilled engineers for cybersecurity or data-science by establishing educational linkage among industry-academia. This scheme mainly targets academic institutes that provide practical programs, such as problem-based learning (PBL).

iii) Tax reduction to IOT investment [10]

'IOT tax system' was rolled out by METI from 2018 to 2020. When enterprises make investments on software, machine, or tools for the purpose of data connection, cybersecurity, or productivity improvement during the period, they receive immediate depreciation of 30% and reduced asset tax of 3%–5%.

For example, a housing products manufacturer installed machinery with sensing devices and data analytic software to balance their line production operation. The result - 96 products were produced in a single line and labor productivity was improved by 16% [11].

Innovative transformations in manufacturing, regarded as part of the social transformation, have been supported by such crosscutting schemes in Japan. Under the umbrella of "Society 5.0", R&D activities, skilled human resources in innovation management, financial support with subsidy, or tax reduction are listed in the menu.

SUCCESSFUL BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

Sectoral Coverage

Three excellent cases from Japan's large manufacturing industry were selected for this section. The selected companies did not merely focus on transformation to take place within their production site alone. In fact, some manufacturers emphasized that their technology coexist with society and community. Some act like service providers, not just as manufacturers, by taking advantage of their resources and technology. However, SMEs were not considered for this paper as many of their achievements are single or small transformations. From the viewpoint of analyzing the ways transformation had tangibly affected the comprehensive corporate strategy, in many cases, neither SMEs have tangibly measured outcomes nor do they have data of gap analysis of the before and after transformation.

In the case studies highlighted here, all corporate information was collected from open sources, such as investor relations (IR) reports, annual reports, and corporate websites.

Case Study 1: Manufacturer of Construction Machinery

This company developed an open platform that offers Smart Construction with their machinery. This open platform stores and manages all construction processes, such as the environment, terrain, materials, operators, climate, logistics, etc. This platform has been provided to over 7,500 construction sites for the purpose of ensuring labor safety and improving productivity where there is serious shortage of manpower. The Smart Construction system also enables young operators to operate machines, like skilled operators, by utilizing the data.

Reason for Adopting The Transformation

Their IR report informs that the cornerstone of the management principle is to commit to quality and reliability, and maximize the total sum of trust by all stakeholders and society, which it defines as corporate value. Maximizing trust requires corporate activities that are based on social responsibility along with efforts to strengthen corporate governance and enhance manufacturing competitiveness. Manufacturing transformation is deemed necessary as one of the platforms to implement the management principle.

Benefits Considered When Considering Transformation

The transformation is considered as a way of enhancing operational structure to achieve corporate goals, especially the quality of products and the reliability of their business. Simultaneously, the company focused on human resource development by promoting its

awareness to all group employees. Such transformation would be considered as a tool to roll out the corporate slogan "The Very Best".

Case Study 2: Manufacturer of the Servomotor

This manufacturer is a market leader of servomotors, which is used for setting parts at a precise position in a semiconductor equipment. This motor acts as a sensor to collect motion data. Sensing and analyzing the internal electric current enables the motor to grasp detailed motions of installed robots and machines. The collected 'big data' of the motions can be utilized to upgrade machine performance and improve the efficiency of its production system.

Reason for Adopting The Transformation

The company's mission is to leverage on the pursuit of business by contributing to the advancement of society and well-being of humankind. To roll out this high-level mission, the company needed to take full advantage of their world-class technology. They also needed to take into consideration their market competitiveness and the environmental changes - geographically, technologically, and economically. The manufacturing transformation was deemed inevitable in achieving the mission.

Benefits Considered When Considering Transformation

One of the expected benefits from the transformation is seen in the improvement of labor productivity. Manufacturers have been facing serious issues in securing workforces and transferring the technical know-how to the next generation in the trend of population downsizing in Japan. Manufacturing transformation was expected to give solutions to maximize outputs with smaller workforce, as indicated in the company's report in boosting operational efficiency as a principle of management.

Case Study 3: Manufacturer of Parts for Factory Automation

A next-generation manufacturing platform was developed by this manufacturer - a patented online service that recognizes 3D shapes based on 3D CAD design data uploaded by the customers, produces estimates, and handles orders. These functions provide smart support for the communication and sharing of information with the contact persons who placed the order from the customers' factories. In turn, this manufacturer delivers precision parts, processed at the micron level, based on efficient and accurate manufacturing instructions.

Reason for Adopting The Transformation

The unique business model as a global 'manufacturing distributor' offered a high competitive edge. They differentiated themselves by accomplishing both build-to-order (BTO) and short lead-time for the supply of small parts. As the business was based on high-mix and low-volume, the key issue for growth was to upsize their market by maintaining the service level of quality, time, and cost.

Benefits Considered When Considering Transformation

The development of the manufacturing transformation was to establish an efficient business process and to apply it globally. About 30 to 40 years ago, when a factory placed an order of equipment parts, it took time because of the sequence of drawings done by hand, estimation works, and production. The factory also needed to look for other suppliers for different parts. In this sense, this manufacturer would expect to make their business process efficient by improving their offering value.

DATA AVAILABILITY

Primary Data - Focus Group Interviews

Due to the spread of COVID-19 in Japan, it was difficult to arrange for interviews with the selected manufacturers. Therefore, this section refers to the information and descriptions obtained from the companies' disclosed annual reports as the primary data.

Case Study 1: Manufacturer of Construction Machinery

This century-old company is one of the world's largest manufacturers of construction and mining equipment. Table 4.4 highlights some pertinent information.

TABLE 4.4

CORPORATE PROFILE OF CONSTRUCTION MACHINERY MANUFACTURER

Year of establishment	1921
Main business	Manufacture and sale of construction and mining equipment, utilities, forest machines, and industrial machinery
Net sales (Fiscal year ended 31 March 2018)	JPY2,700 billion (about USD25 billion)
Group	258 other companies
Number of employees	62,000 (consolidated)

Source: Company's Corporate Profile, accessed June 2020.

The overall corporate goal in 2021 is to achieve the mid-term management plan which is "'The Very Best' - Value Forward Together for Sustainable Growth". This consists of the combination of the company's products, services, and solutions that target the global distributor network along with cultivation of distributor personnel as well as brand management.

Smart Construction is demonstrated in this plan - installing digital technologies into all equipment, including conventional equipment already on the market, sophisticated ICT-intensive equipment that is able to function as "command towers", facilitating communications between equipment as all equipment collaborate to carry out the work instructions issued by the digital platform.

The CEO stated in the annual corporate report that "the keywords will be workplaces and links. Workplaces refer to a place where anyone related to works, including the sites of customers, distributors, and suppliers worldwide. This term also encompasses our internal production sites, R&D facilities, sales, service, and administration offices. The links we seek to form go beyond simply the IoT technology. Linking means aligning people along the same vector toward one direction and getting a job done with a strong sense of teamwork" (Corporate Annual Report 2019).

Case Study 2: Manufacturer of the Servomotor

This company is one of the world's largest manufacturers of industrial robots. Table 4.5 shows the corporate information that is found on its corporate website.

TABLE 4.5

CORPORATE PROFILE OF SERVOMETER MANUFACTURER

Year of establishment	1915
Main business	Manufacturing motors, controllers, inverters, robots, and system engineering
Net sales (Fiscal year ended February 2020)	JPY400 billion (about USD3.8 billion) (consolidated)
Number of employees	15,000 (including temporary employees) (consolidated)

Source: Corporate website, accessed 3 June 2020.

In 2019, this manufacturer set their corporate visionary paper "Vision 2025" as their long-term management plan and "Challenge 2025" as the mid-term. Vision 2025 states that the company will contribute in solving the customers' managerial issues as well as to create new added values to society through the evolution of its core businesses, and expansion into new fields by applying mechatronics technology. The company's open innovation system in the field of motion control, robotic technology, and power transformation will be applied both in the automation and optimization of factories, and in new fields of mechatronics application for sustainable social development.

Challenge 2025 from the company's Corporate Strategic Plan sets some tangible indicators for 2021 and three basic policies.

i) Transform the business model

   Meet customers' needs by centralizing the technology and product development functions that will collect necessary data via real-time feedback.

ii) Maximize profitability in the growing robotics business field

   Promote business expansion in the rapidly growing robotics market in consumer products, automobile, and semiconductor industries'.

iii) Expand new domains by strengthening resources through "selection and concentration"

Centralize resources to fields where the strength of mechatronics technology can be leveraged and accelerate expansion of new business domains.

The Representative Director indicates "there's no doubt that the trend of collecting, analyzing, and using data is going to take off at a tremendous pace, and the time is coming again when the company needs a forward-looking business concept (Vision). We will continue to drive the evolution of production from short-, medium-, and long-term perspectives in the Fourth Industrial Revolution, which aims for an optimal production system in a data-driven society. Now that the basic theory of AI is widely shared, the key to AI is its utilization and application. We believe that our company's corporate culture of working with customers to solve on-site problems provides a significant advantage in becoming a company that can provide more and more ideas on what to do with AI." (Corporate Annual Report 2019).

Case Study 3: Manufacturer of Parts for Factory Automation

This company is a manufacturer and a distributor in the manufacturing industry. The businesses are (i) factory automation that mainly carry standardized components for automated equipment used in factory automation and other applications; (ii) die components, where die and mold parts are used to make automobiles and electronics devices; and (iii) variation and one-stop-center with New Alliance Business, which sells third-party brand products under a new distribution business model. In the past, manufacturers had to create drawings to order each individual small part and suppliers required two to four weeks lead-time. Alternatively, this manufacturer prepares semifinished parts in their catalog and undergoes a finishing process before delivering the parts. Lead-time is now shortened to one to two days.

The business standardized over 20 million mechanical parts in their web catalog, which enables customers to receive parts very quickly after placing order. This saves the customers' procurement costs and a significant amount of time.

TABLE 4.6

CORPORATE PROFILE OF FACTORY AUTOMATION PARTS MANUFACTURER

Year of establishment	1963
Main business	Development of group management strategies, administration, and all functions related to group management
Net sales (Fiscal year ended 31 March 2019)	JPY330 billion (USD3 billion)
Number of employees	12,000 (as of 31 March 2019)

Source: Corporate website, accessed 4 June 2020.

According to the CEO, they will continue their business model evolution that is adapted to digital manufacturing. He also mentions that despite concerns of an economic slowdown, from a long-term perspective, advancement of digital manufacturing will be accelerating globally, and the trend of automation remains unchanged (Corporate Annual Report 2019).

Secondary Data - Sources

This section explains the business strategies of the benchmarked three enterprises on eight aspects: economic alignment; technology utilization; talent development; supply chain collaboration and partnership; market competitiveness; innovation ecosystem; strategic management, and regulation of operations. All the data and information were taken from open sources.

Case Study 1: Manufacturer of Construction Machinery

A. Economic Alignment

This manufacturer places over 200 distributors in 146 countries. Machine population over the past 10 years is about 570,000 units. Spreading globally, the manufacturer was faced with the challenge to analyze customers' demand timely by monitoring operations.

A newly developed system can remotely control wasteful operation hours, man-hours, and timely catch part numbers producing at present and machine condition. The system is also utilized to identify the asset management of leased machines.

B. Technology Utilization

The aforementioned open platform digitalizes the construction process, establishes a partner ecosystem where they get technical support, develop new businesses, marketing activities, and so on. About 57 enterprises from various sectors have joined in this network. Originally a vehicle manufacturer, the manufacturer has created a new domain as a construction data service provider.

The important proposition is, as the CEO indicated, IoT aligns people along the same vector toward one direction and gets a job done with a strong sense of teamwork. IoT is sometimes regarded as a symbol of staffless workplace, but IoT is defined as a tool to link people.

C. Talent Development

The manufacturer sets a slogan of the strengths, the beliefs supporting these strengths, the basic attitudes, and patterns of behaviors established based on the experiences of their predecessors as they proceeded to tackle challenges. To run a business on a global scale, it will be crucial to share and repeat the aforementioned slogan to employees with different cultures and customs around the world, and to implement these principles in a manner that aligns employees along the same vector. Based on this philosophy, the manufacturer proceeded with quality control (QC) circle activities or trainings to distributors. Sharing such consensus will work as a principle for all the members' decisions.

D. Supply Chain Collaboration and Partnership

This company has been collaborating with their 2,700 suppliers to strengthen their supply chain. Under the previous mid-term management plan, the manufacturer endeavored to create connected plants in which all processes, production to sales, were linked using IoT

technologies and coordinated into cycles in real time. Through these activities, data from the machine tools, welding robots, and suppliers is collected via the network to be used to track metrics and improve efficiency across the entire value chain.

E. Market Competitiveness

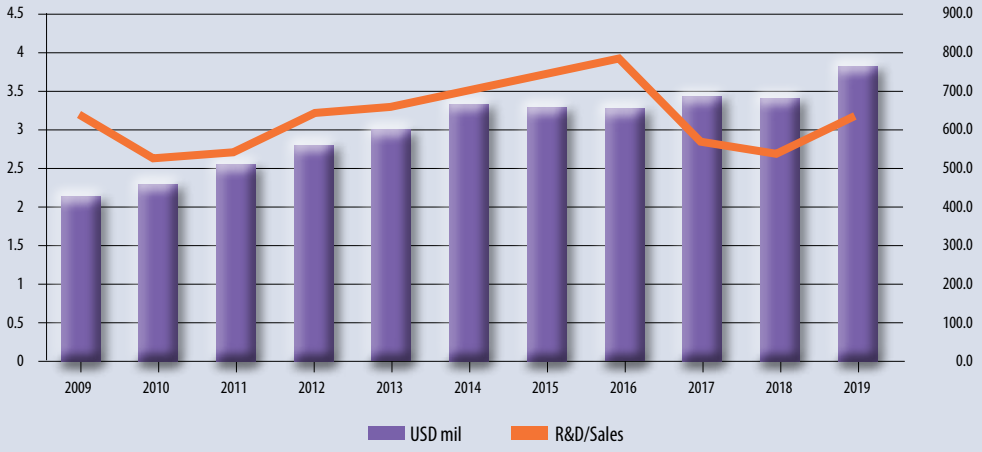
The company's keyword in competitiveness is "The Very Best". They use this phrase as their major strength, such as 'the very best product' and 'the very best solution'. This provides advantages to both the manufacturing competitiveness and brand management. The manufacturer believes that the maximum corporate value through their quality and liability is equal to the trust given by all the stakeholders and a society. "Brand management" is defined as all activities that make themselves indispensable to the customers. To accomplish this, they visit workplaces to understand the ideal state of their customers and to build relationships that enable them to work together and help achieve their goals.

F. Innovation Ecosystem

The company develops and produces the key components in-house. On the other hand, the aforementioned open innovation platform integrates their technology with external resources. The history of their R&D expenses illustrates the importance of the investment to growth areas in this company. The expense has been steadily increasing, though there are some up-downs in the ratio of R&D expenses to net sales.

FIGURE 4.9

R&D EXPENSES



Source: Company's Corporate Profile 2019

G. Strategic Management

This manufacturer sets key initiatives and its key performance indicators (KPIs) of 2021 under their New Mid-term Management Plan. Some of them are set for manufacturing transformation as the following:

- ICT-intensive equipment introduced: 1,590 units (per year)
- Sites adopting Smart Construction: 4,850 (per year)
- Sales in the platform business: 1,900 (per year)

On the other hand, they identify risks to achieve these goals. Below are the risks that affect their manufacturing transformation.

- **Information security** - The manufacturer's platform collects information of all machinery and equipment. High productivity is achieved by connecting these information. However, the disadvantage of that is that their knowhow or operation-related data may be vulnerable to leaks due to system breach or hacks
- **Procurement and operation suspension** - Due to the spread of COVID-19, materials and devices may not be adequately supplied to their production sites. Manpower may be insufficient to avoid an infection cluster. Readiness to secure the production and R&D globally is one of their key issues in post-pandemic future

H. Regulation of Operations

In the midst of changes to the operating environment, this manufacturer stays committed to quality and reliability, aims to maximize the corporate value, and the total sum of trust from society and all the stakeholders under the new mid-term management plan. To this end, they work for sustainable growth through a positive cycle of improving earnings and solving ESG issues, which is driven by growth strategies.

Smart Construction will contribute to the realization of safe, productive, and clean workplaces that will earn them increased trust from all their stakeholders.

Case Study 2: Manufacturer of the Servomotor

A. Economic Alignment

The mid-term management plan "Challenge 25" demonstrates three basic policies. One of them is Selection and Concentration. To take advantage of their technology in the mechatronics field, the manufacturer identified four major domains - energy saving, food & agriculture, clean power, and humatronics (natural interaction between human and system). These domains are prioritized for the most effective use of their resources.

B. Technology Utilization

This manufacturer began the full utilization of digital data and introduced a new concept of digitalization by offering new values at the manufacturing scene in 2017. This concept consisted of three "I" steps:

- Integrated - Production automation through integration of components
- Intelligence - Data management and utilization at production sites
- Innovative - Digital solution to realize intelligent factories

At the "Intelligence" step, an original, developed software tool collects, visualizes, accumulates, and analyzes big data generated at production sites. This software digitizes labor-intensive works and enables real-time visualization of production conditions, such as production load and material allocation to orders, to achieve overall optimization.

C. Talent Development

The manufacturer's human resource policy describes the basic concept of their human resources and personnel systems.

- **Expectations for human resources** - Lookout for talents who are professionals and keep challenging new things while cooperating with others without fear of failure
- **Human resource development** - Opportunities are provided to face challenges and growth so that each employee can realize his or her own goals through self-development, on-the-job learning, and off-the-job learning
- **Evaluation and compensation** – Enhance transparency by creating a system in which people who work hard and achieve results are evaluated and disclose the information on evaluation standards

D. Supply Chain Collaboration and Partnership

This manufacturer established two domestic R&D centers and five factories. Their global network spreads to 30 countries. No specific partnership is explained in their reports except the open innovation scheme in their technology center. However, as Selection and Concentration indicates, this company focuses on specific products and regions. They allocate the production and the sales process globally for maximizing their output.

E. Market Competitiveness

The manufacturer's digitalization is an integrated solution system that collects big data from their customers. The data is analyzed in real time at the customers' site. Therefore, once the system is connected with customers' site, it is difficult to replace another system due to its high switching cost.

F. Innovation Ecosystem

There are plans to centralize the R&D functions into a single technology center. All the core technologies will be connected and this contributes to their consistent development process from the underlying technology to prototyping. The center will also be a space of

open innovation with external enterprises or academia. It is also expected to be a showcase of timely development, fulfilling various customers' needs.

G. Strategic Management

The mid-term plan "Challenge 25" (2019–2021) indicates the time-series of what they achieved and what they will achieve. Based on their achievements in their previous mid-term plan, they set the next goals:

TABLE 4.7

TIME SERIES OF MID-TERM MANAGEMENT RESULTS AND THE NEXT GOALS

Goal	Dash25 (2016–18) Goal of 2018	Dash25 (2016–18) Result of 2018	Challenge25 (2019–21) Goal of 2021
Net sales (USD)	4.2 billion	4.4 billion	5.0 billion
Operation income (USD)	0.42 billion	0.46 billion	0.65 billion
Op. income ratio	10.0%	10.5%	13.0%
Return on equity (ROE)	Over 13.0%	17.1%	Over 15.0%
Return on invested capital (ROIC)	-	-	Over 15.0%
Payout ratio	Over 27%	33.4%	Over 30.0%

Operation income is set as the most important KPI for realizing their long-term management strategy of "Vision 2025". The sales and income targets of the strategy are broken down and cascaded to each product segment.

H. Regulation of Operations

This manufacturer categorizes their capital as Intellectual Capital, Human Capital, Social and Relationship Capital, and Natural Capital, in addition to finance and manufacturing. These capitals are tied with their management strategy and KPIs.

- Intellectual Capital: USD1.9 million of R&D investment
- Human Capital: 78% of employees who feel it is rewarding to work
- 34,329 visitors to the innovation center per year
- Natural Capital: 11.71 million tons of CO_2 emissions are controlled through the products cumulatively since 2016

The manufacturer's overall goal is to make profit. However, the profit is generated after their contribution is made to stakeholders. The business growth and sustainability rely on how they cope with external resources. In this sense, their concept aligns smoothly with both Industry 4.0 and Society 5.0.

Case Study 3: Manufacturer of Parts for Factory Automation

A. Economic Alignment

Both functions of manufacturing and distributing mechatronic parts is the unique feature of this manufacturer. The number of customers steadily increased from about 100,000 in 2008 to 301,000 in 2018. At the customers' factories, missing even one machine component may delay a production line. This manufacturer eliminates the inefficiencies in their customers' process of procurement by offering a quick delivery system. In other words, they provide time-based value.

B. Technology Utilization

The manufacturer uses an original method of catalog - make-to-order (MTO) products - that formerly had to be first drawn for ordering. The convenient, reliable, and quick delivery of online ordering by model number without drawings as well as the provision of associated CAD system resolves customer inefficiencies.

C. Talent Development

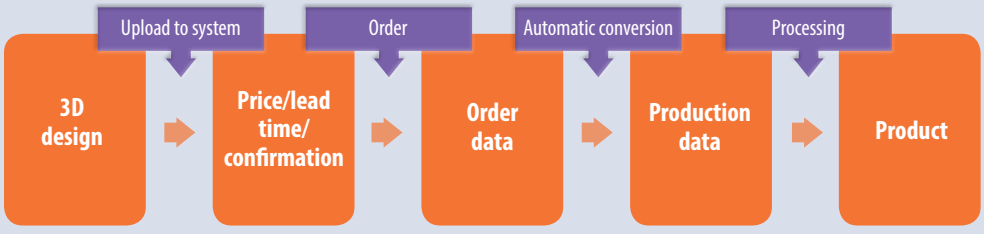
This manufacturer focuses on supporting talent development of the next generation in the manufacturing industry. They have sponsored a global bipedal-robot fighting tournament since 2016 to support the passion of people involved in manufacturing. They also solicit applications from students by providing their products free of charge. These activities have drawn more youths' interest to manufacturing as a way to secure human resources for the next generation.

D. Supply Chain Collaboration and Partnership

The biggest advantage in parts distribution is the short lead-time delivery. A newly developed MTO system enable customers to obtain a quotation instantly. The shortest shipment is ready in one day, when previously, this process of ordering parts would have taken weeks to complete.

FIGURE 4.10

PROCESS OF THE MTO SYSTEM



E. Market Competitiveness

This manufacturer deals with over 20 million parts. The total number of its combination becomes 1,080, including size variation as such parts are regular MTO products. It is impossible to store such large number of parts for short-time delivery. To realize this, they mass-produce semifinished products at factories. Then the products undergo a final process at the customers' premises once they receive an order. Such semifinished products are listed in the catalog as their standard items.

There is another Japanese distributor with a similar business model, but their market area is limited to Southeast Asia. The case-study manufacturer services customers from all over the world. E-commerce giant Amazon may pose to be another potential competitor in distribution, but they do not have a factory. One of the manufacturer's advantages is that they can make small products based on the customers' detailed requests by using their own production machinery.

F. Innovation Ecosystem

There is no detailed information about R&D strategy in their reports. However, it was highlighted that the R&D annual expense was USD14.5 million in 2019. This accounts for sales turnover of 4.8%. The CEO mentions "they recognize the advancement of digital manufacturing is accelerating globally and the trend toward automation remains unchanged. Therefore, we will continue to advance business model evolution adapted to digital manufacturing." As their unique and competitive business model shows, they already created a corporate culture and established internal scheme for change management.

G. Strategic Management

Even during deterioration in the manufacturing industry, this manufacturer deploys their globally reliable and quick delivery business model to build a stronger customer base. The number of global customers increased by 9.8% year-on-year, forming the foundation for possible further growth when the economy recovers. The advancing trend of digital manufacturing in the manufacturing industry will endure and continue to make upfront investments aimed at business model innovation which is in line with this trend while carefully selecting investment themes.

The manufacturer leverages its competitive advantage by simultaneously encompassing both manufacturing and distribution as part of its model innovation, in tandem with globally advancing digital manufacturing. In doing so, the manufacturer strengthens their response capability toward the manufacturing industry and IT by revolutionizing e-distribution of production materials.

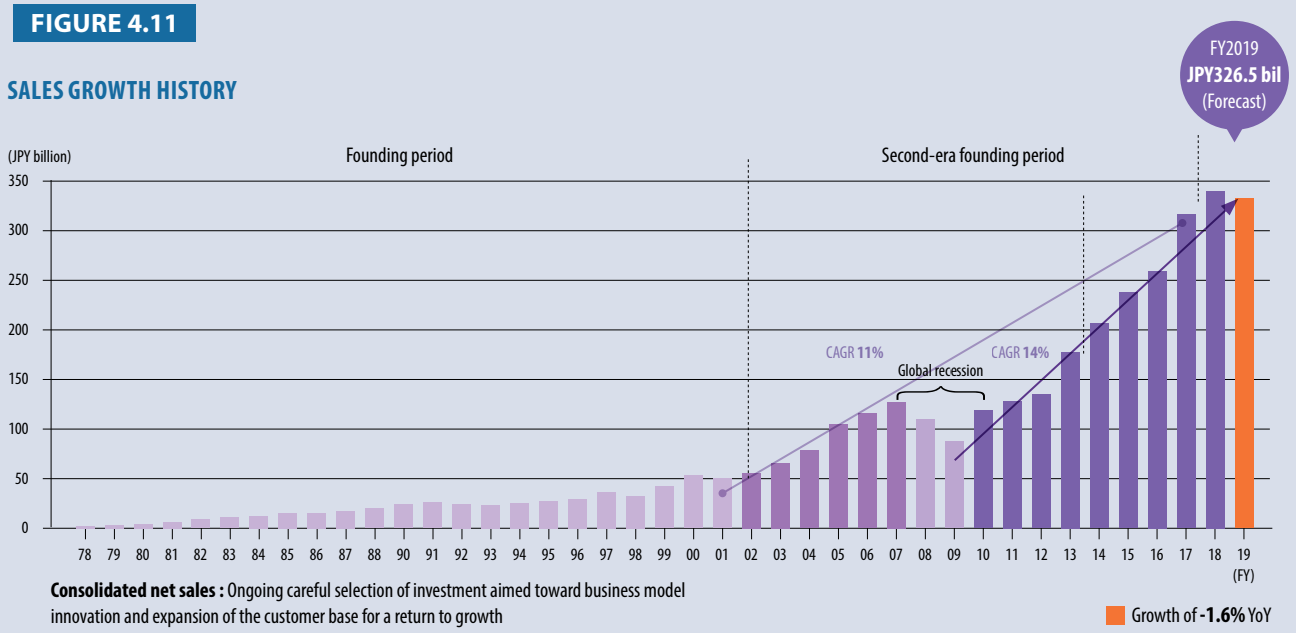
H. Regulation of Operations

Further to the support of youths' talent development, the company recognizes themselves as a member of society. They operate the company based on three policies:

- Reduce environmental load and prevent pollution in business activities
- Comply with environmental laws, regulations, and other requirements
- Regularly review environmental targets and continuously improve on them, complying with ISO 14000

FIGURE 4.11

SALES GROWTH HISTORY



Source: Company's corporate website, accessed on 10 June 2020.
Note: FY1989 has been omitted due to a change in the book closing period that year.

ANALYSIS OF CASE STUDIES

The two methodologies, Strategic Map and Strategic Dynamics, demonstrate the corporate management strategy based on the identified characteristics of the three Japanese enterprises. The analysis consists of four steps: (i) Balanced Scorecard (BSC) strategy map for diverse performance indicators; (ii) Strategy Dynamics for quantified performance over time; (iii) qualitative factors and improved performance; and followed by (iv) performance gap and reflections for continuous improvement.

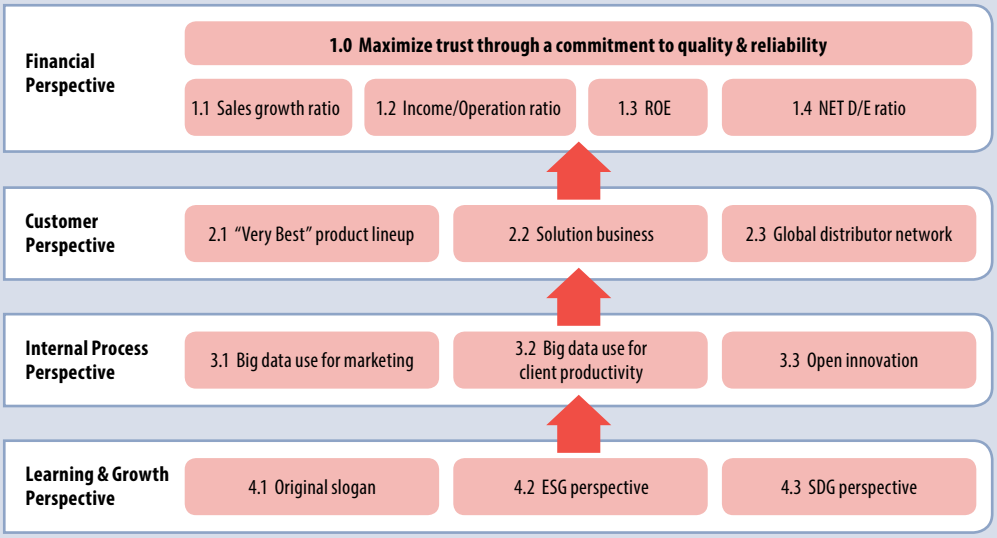
Analysis of Case Study 1: Manufacturer of Construction Machinery

i) BSC strategy map for diverse performance indicators

The aforementioned information and data are organized as the strategy, shown in Figure 4.12.

FIGURE 4.12

STRATEGY MAP OF CONSTRUCTION MACHINE MANUFACTURER



ii) Strategic Dynamics for quantified performance over time

Some of the key tangible items in the Strategy Map are plotted in the Strategic Dynamics. Additional items from disclosed reports are also added in the Dynamics. As far as the disclosed data indicate, operation income and net sales are linked to market demand. Such adequate catch-up with the market trend seems to rely on their stable R&D expenses and the investment to production facilities. In fact, their open platform system and other innovative business processes are the outputs of the R&D activity. The new values created by the manufacturing transformation reflect the current financial achievements. Depending on how the market demand shifts, the company's steady implementation of their mid-term strategy will allow them to achieve the targetted goals.

The sales ratio of business solution (undisclosed) field must be a core indicator for evaluation if the manufacturing transformation has been successful, or otherwise. As this manufacturer indicates the sustainable growth in the mid-term management plan, indicators related to social inclusive growth, such as investments to the environment and sponsoring community events, will be part of their brand management to maximize trust from stakeholders.

iii) Qualitative factors and improved performance

The overall goal is achieving trust, quality, and reliability in "The Very Best" level. To achieve this, their consistent processes from procurement to sales require more real-time needs of customers.

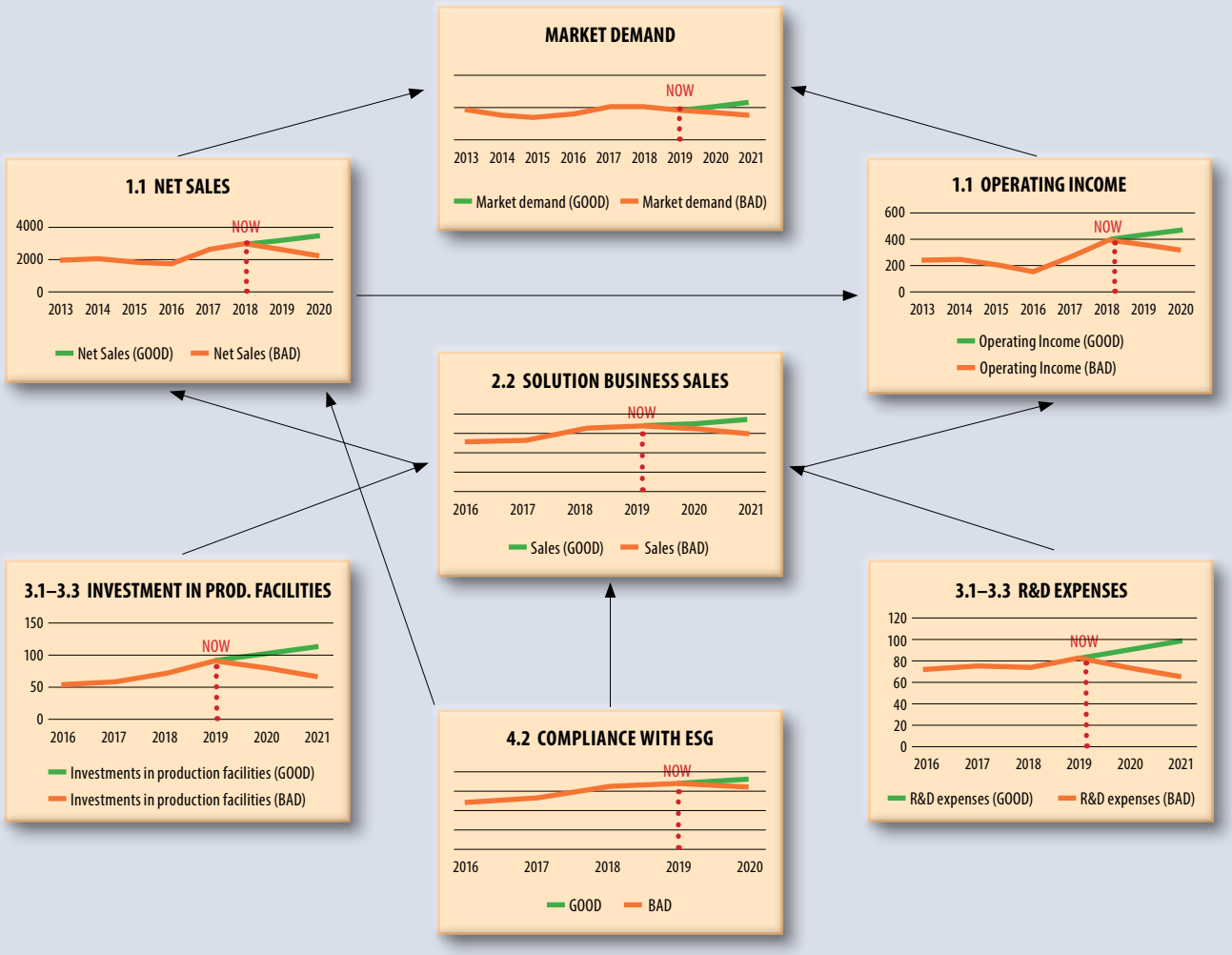
The open platform, developed by the collaboration with external excellences, has realized Smart Construction through storing and managing all the construction processes remotely. This system inevitably places their workstations closer to the customers' sites by collecting data which enables timely solutions out of the broad knowledge database in the system. In this sense, this manufacturer has been transforming to become the "very best" solution provider, as opposed to machine supplier.

The new system requires talents who can operate the machines and the code of conduct is set as the manufacturer's corporate slogan. Their QC circle activities focus on total quality management, for both product quality and quality of all work processes.

The corporate strategy also emphasizes their commitment to ESG issues and relevant UN's Sustainable Development Goals (SDGs). The manufacturer's Smart Construction system is expected to realize safe, productive, and clean construction sites.

FIGURE 4.13

STRATEGIC DYNAMICS



The best scenario

The manufacturer achieves all tangible and intangible goals in the best scenario. They get full trust, quality, and reliability from all stakeholders. In this scenario, as the Strategic Dynamics illustrates, a key factor is on how they catch up with demands by making use of the data in open platform. Adequate application of big data will bring real-time demands from all construction sites. That system will help them make a precise forecast and manage production efficiently. This also provides quick feedbacks, just like an experienced supervisor would do. Such speedy and professional service will improve the reliability of customers. Smart Construction will manage all the vehicles, equipment, and materials in a very effective way, which may create environmental-friendly construction sites too.

The worst scenario

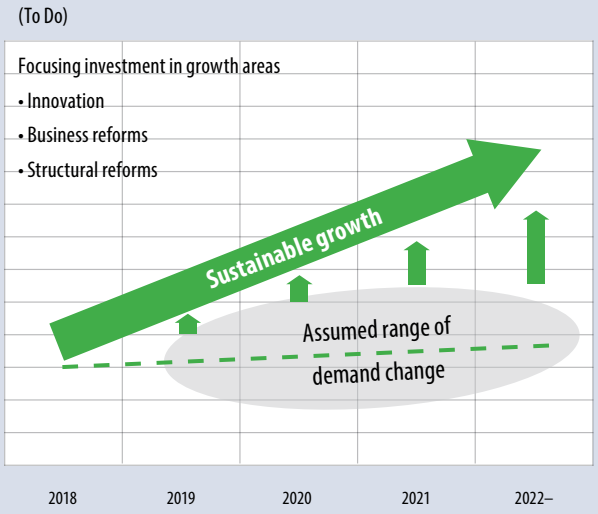
Most of the goals are not achieved in the event the manufacturing transformation (R&D and investment to production facility) do not function well due to whatever reasons they may be. Without transformation, it will be difficult to catch real-time demands or to reflect them to their business operations timely enough to deliver "the very best" solutions to their customers. Such situation will effect adverse financial outcomes as well.

iv) Performance gap and reflections for continuous improvement

Tasks to their further growth are identified in their mid-term management strategy (2019–2021). They aim at "gradual growth in the mid to long-ranges, though the volatility will remain high in the short range". To date, the COVID-19 pandemic has been giving serious impact to the construction and manufacturing sectors. They will focus on investing in growth areas accompanied with innovation, business reforms, and structural reforms to strategically tackle such volatilities.

FIGURE 4.14

GAP ANALYSIS



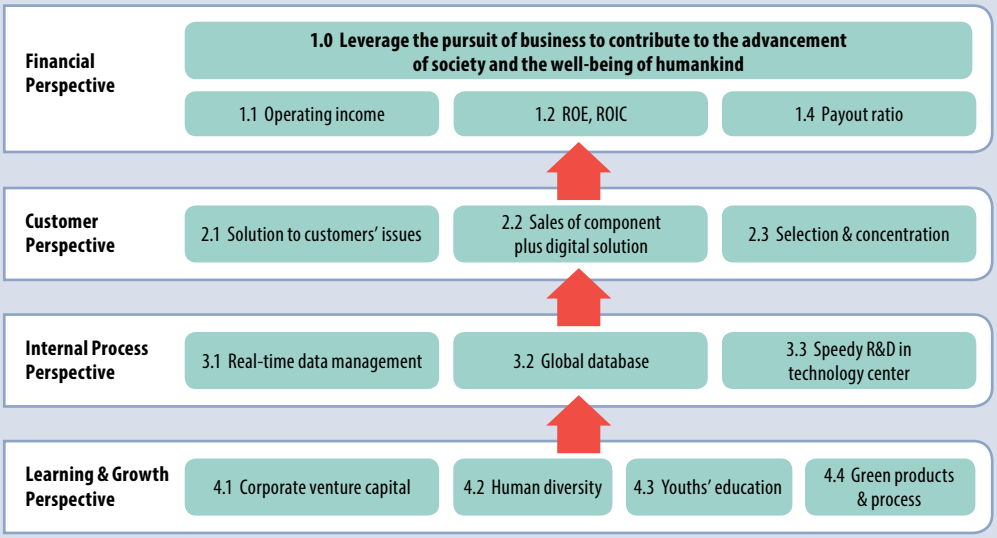
Analysis of Case Study 2: Manufacturer of the Servomotor

i) BSC strategy map for diverse performance indicators

The information and data for the servomotor are organized in the strategy map, shown in Figure 4.15.

FIGURE 4.15

STRATEGY MAP OF SERVOMOTOR MANUFACTURER



ii) Strategy Dynamics for quantified performance over time

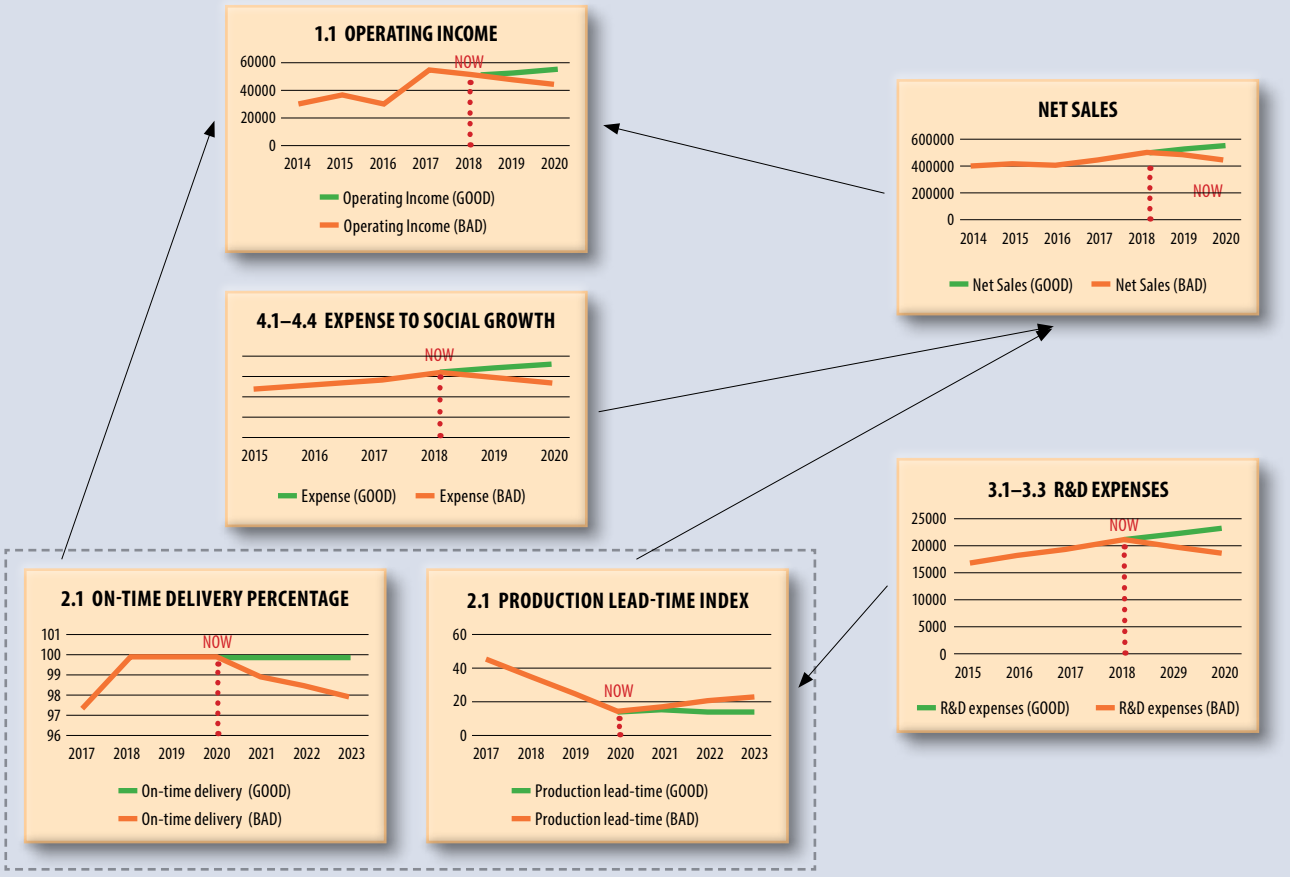
Some of the key tangible items in the Strategy Map are plotted in the Strategic Dynamics. Additional items from disclosed reports are also added in the Dynamics. This manufacturer sets the operating income as the key indicator of their management strategy. According to the disclosed data, the income trend has been on the increase, and the net sales are almost on the same track. The manufacturing transformation has improved their productivity in terms of production lead-time and on-time delivery. The productivity improvement directly affects the financial scores.

The increasing R&D expense gives indirect impact to the financial achievements by realizing the business process innovation of shortening production lead-time and on-time delivery.

Their steadily increasing expense (or investment) to in-house venture capital, humanity, youths' education, and green environment is part of the company's CSR programs which demonstrates its corporate philosophy. Such continuous investment will boost their brand image and will contribute to the increase in sales.

FIGURE 4.16

STRATEGIC DYNAMICS



iii) Qualitative factors and improved performance

Corporate mottoes - "Enhance world-class technologies", "Boost management and operation efficiency", and "A customer centric organization"- are the drivers of this manufacturer. In addition to these direct values toward customers, they regard society and humankind as important stakeholders.

They emphasize the operating income and its ratio as the most important KPI. To maintain a constant level of financial leverage and further improve the return efficiency for shareholders, the manufacturer has also adopted return on invested capital (ROIC) for the efficiency of invested capital, including interest-bearing debt.

The advancement of data collection via their open platform enabled them to act as a solution provider. They are presently in the stage of applying this scheme to new industries under the Selection & Concentration strategy.

To achieve the KPIs, the manufacturer has developed a real-time management system by using AI data analytics and has made it accessible globally. Their designated R&D center is a key control tower to apply the data to improve their production system.

The overall goal is to create social values, as indicated in the management principle (1.0 of the strategy map). The corporate capitals are categorized into four types - financial capital, natural capital, and social and relationship capitals to measure its efficiency in the management. They have also identified the linkage between their business activities and relevant SDGs. From the viewpoint of human capital, they established a corporate venture capital to drive internal new value creation.

The best scenario

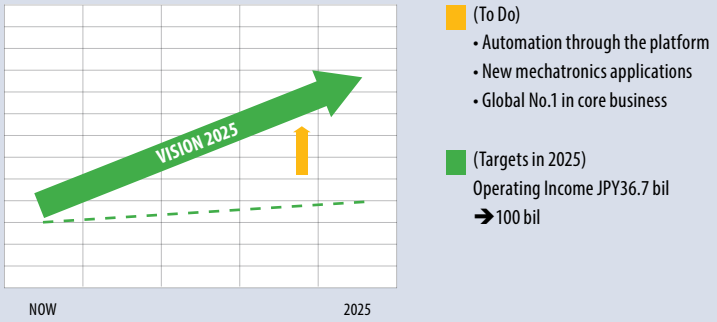
In the best-case scenario, the manufacturer would have achieved most of the tangible indicators in the mid-term management strategy. The improvement of those indicators will drive their development for further automation and application to new business fields under their Selection & Concentration concept. New identified business domains are in energy saving, food & agriculture, clean power, and humatronics.

The worst scenario

In case their manufacturing transformation through the platform does not go successfully, it would be arduous to achieve the mid-term goals. Without sensor-collected data or its proper analyzing system, they may miss customers' demands or new business opportunities because those are the key components for real-time analysis and quick feedback to the R&D.

FIGURE 4.17

MID-TERM TARGET AND THEIR PERFORMANCE



iv) Performance gap and reflections for continuous improvement

This manufacturer sets several financial targets in the mid-term management strategy. To achieve these, newly developed open platform are promoted further to combine mechatronics and ICT technology, and provide new solution to automation. They will determine business commercialization by exploring and demonstrating potential fields

where mechatronics technology can be applied. They also pursue and achieve global number one share in robotics and motion control segments. The achievement will rely on the success of these activities.

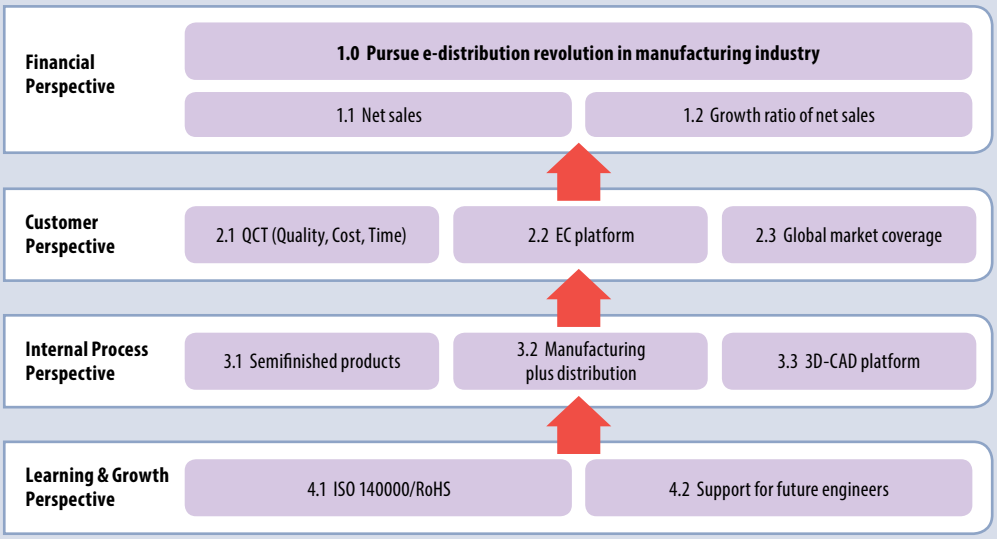
Analysis of Case Study 3: Manufacturer of Parts for Factory Automation

i) BSC strategy map for diverse performance indicators

The information and data are organized in the strategy map, shown in Figure 4.18.

FIGURE 4.18

STRATEGY MAP OF FACTORY AUTOMATION PARTS MANUFACTURER



ii) Strategy Dynamics for quantified performance over time

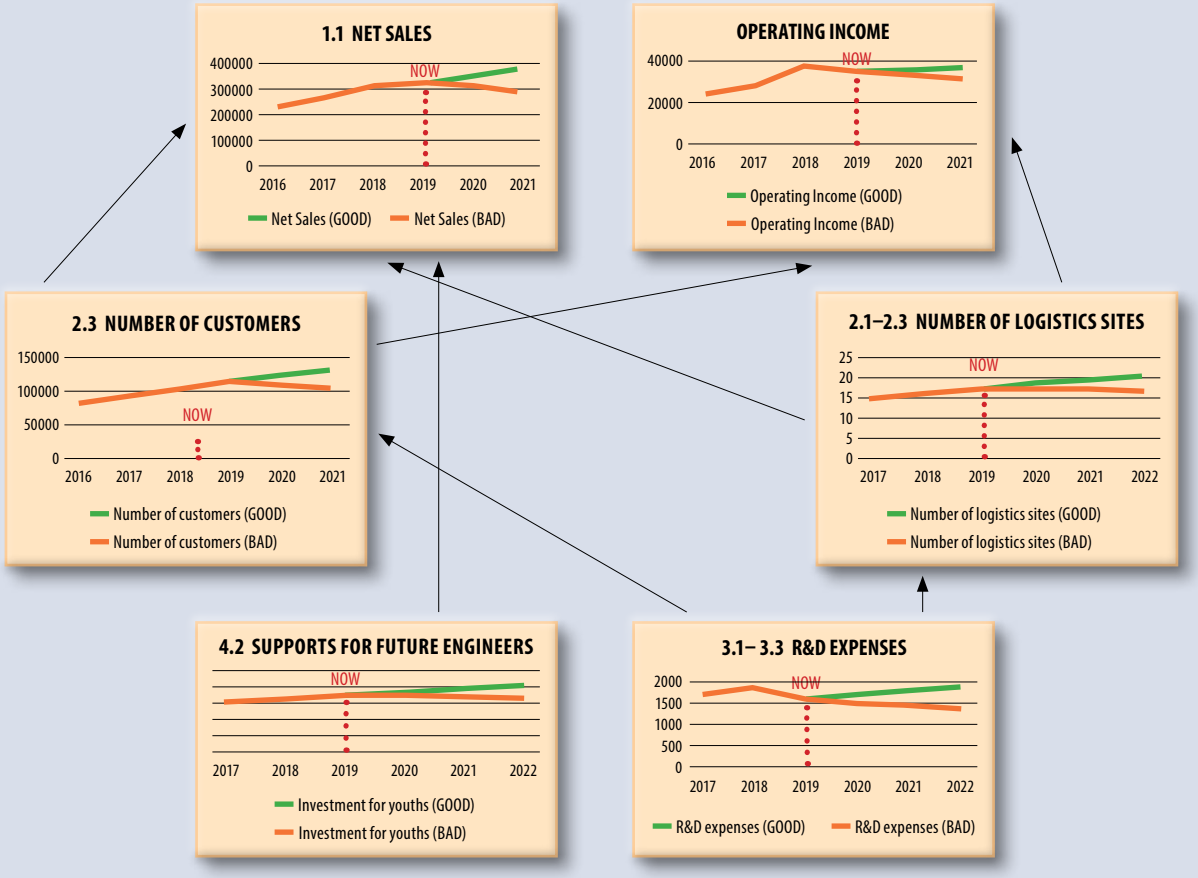
Some of the key tangible items in the Strategy Map are plotted in the Strategic Dynamics. Additional items from disclosed reports are added in the Dynamics. The operation income decreased in the previous year despite the stable increase of the net sales among the number of customers. As the strategy for the next period indicates the enhancement of their strengths to further expand the global market, the number of logistic sites will affect the cost and time value for clients. Securing R&D expense appears as key to improve their technology and a differentiating business model from others. From the viewpoint of social-inclusive management, their investment to human resources, especially to future engineers, will act as their brand ambassador to get reliability from the society.

Their global competitiveness has brought outstanding growth in the past. However, that means geographical issues directly affect operation management. COVID-19 has made their customers and logistics systems shut down, but their former-planned strategy of

having a new logistics site will enhance their competitiveness of stable delivery. Their unique business model goes well as far as their implementation of quality, cost, and time (QCT) concept supports customers' digitalization.

FIGURE 4.19

STRATEGIC DYNAMICS



iii) Qualitative factors and improved performance

The manufacturer's goal is to contribute to the manufacturing industry with quick and reliable distribution. They indicate the net sales and its growth ratio as indicators.

In their unique business domain as a component manufacturer and distributor, the business acts as a solution provider for customers' procurement issues. Customers all around the world can choose from millions of components and order the necessary one through the platform. As their slogan on reports "It's all about TIME" indicates, the reliability and quick delivery to the global market has high competitive edge. They call this as the strategic excellence of QCT.

They produce semi-finished parts as their standardized line-up to reduce inventory risk and to do extra detailed processes at the nearest factory of customer sites. Their 3D-CAD platform eliminates time for quotation and designing processes.

As a global distributor, they have high awareness on avoiding environmental pollution. The business has set the environmental policy and the green procurement guidelines to declare about environmentally conscious products, management of chemical substances, and ISO 14000 activities. They are also keen on supporting the talent development of the youth.

The best scenario

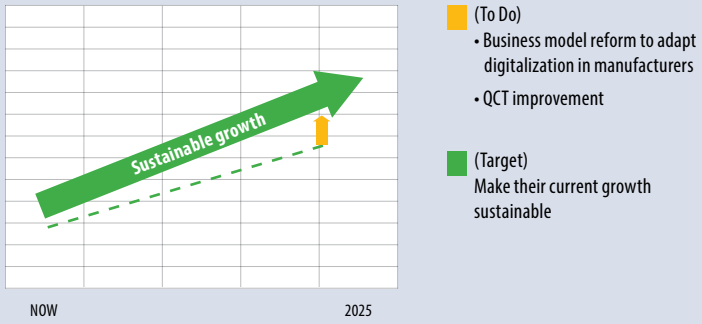
Sustaining their uniqueness and competitiveness is the most successful scenario. As long as the one-stop platform of part-ordering functions improves their QCT elements, they will be on the track of sustainable growth. The manufacturing transformation will keep them competitive in the global market as a pioneer.

The worst scenario

As the manufacturer has been offering high value to their customers, it is difficult to imagine rivals in the market. However, in the event the manufacturer's system goes wrong due to some unexpected events or reasons, customers will face serious inconveniences in their procurement process. That will suppress the number of customers and logistic sites.

FIGURE 4.20

PLANNED GROWTH TRAJECTORY



CONCLUSION

To conclude, several characteristics are indicated from two aspects - enterprise and government levels.

Enterprise Level

i) Manufacturing transformation is connected to ESG solutions

One of the common characteristics shared by the enterprises is that they identify their stakeholders and the values offered to them. The stakeholders are not limited to customers

or shareholders, but to the entire society. Therefore, the management strategies make a strong commitment to satisfy the ESG issues. They also show how their products and services correspond with the solution of SDGs issues. Their manufacturing transformation must be churning profit, but it is also strongly linked to the sustainability of their business ecosystem. This tendency aligns well with the Japanese concept, Society 5.0, which means the betterment of the whole society with advanced technologies.

ii) Manufacturing transformation as business model transformation

Manufacturing transformation changes process, products, and business models of the businesses highlighted in the case studies. In other words, the aim is not to merely improve the manufacturing systems, but act as an integrated solution provider by reforming the manufacturing system. Collected real-time data is analyzed, issues identified, and timely appropriate solutions are provided. The manufacturers seem to offer a seamless solution package. Once such package is accepted and installed at customers' site, it is not easy for them to replace to another due to high switching cost.

iii) Risks in manufacturing transformation

The manufacturing transformation collects and centralizes an enormous amount of data. This inevitably requires the highest level of information security. Once customers' data or technical information is leaked or maltreated, the ensuing problems may severely damage the whole enterprise.

In addition, a specific business risk in remote management must be taken into account. AI has been replacing analysis or communication process recently. Some part of these processes relies on AI's thinking thus the liabilities of AI must be clarified. Some example questions pertaining to this are: Who takes responsibility should a factory worker in Vietnam is seriously injured due to a misinstruction from the supplier's AI system in Japan? What if the AI is developed by a German enterprise?

In the medical field, a medical association noted that any mandates requiring the use of healthcare AI should hold developers responsible for potential liabilities [12]. This means service providers, not users, must take responsibility against any potential risks. A legal protocol across countries will be a critical issue in the manufacturing industry.

Government Level

i) Clear strategy and advocacy in the era of high volatility

Due to the worldwide spread of COVID-19, manufacturers have been experiencing a very tough period in their operation. Post-COVID-19 era will require the rather drastic change of behavior. For instance, employees may need to stay home; it may take double time for custom clearance; and/or customers will prefer to electronic contracting. The manufacturing transformation will increase productivity with minimized human interventions, replaced by AI and other technologies in a supply chain. A new working culture under COVID-19 will also facilitate the transformation from the viewpoint of securing labor safety and hygiene.

Even small manufacturers have come to introduce the remote-working style to their production lines.

In a period of such high volatility, the government is expected to set clear strategies and advocate them to the nation. Diverse stakeholders are involved in a single enterprise operation as stockholders, employees, family members, and so on. As in Japan's case, manufacturers recognize themselves as a member of society. They emphasize on both sustainable growth of themselves and betterment of the people. In this sense, manufacturing transformation is an inclusive issue, which should be considered as a socioeconomic viewpoint. This is also in line with the government's Society 5.0 agenda which encompasses diverse ministries from economy, technology, welfare, and education under one umbrella.

ii) Supporting SMEs' innovation creation

Three large manufacturers are introduced as successful cases in Japan. As the cases indicate, large manufacturers have enough capital and capability for in-house transformation. On the contrary, SMEs generally have limited resources to afford such transformation. However, Japanese municipalities do provide support to SMEs, in assisting them to drive their manufacturing transformation. The support comes in the form of funding scheme for IoT software, facilitation of open innovation, access to training programs, and/or hands-on support by mentors.

CHAPTER 5

MALAYSIA

INTRODUCTION ON INDUSTRY 4.0 IN MALAYSIA

Malaysia launched its National Policy on Industry 4.0, known as Industry4WRD, on 31 October 2018. Industry4WRD is Malaysia's response to the call for digital transformation in the manufacturing sector and its related services. Its function is to facilitate companies to embrace Industry 4.0 in a systematic and comprehensive manner, and be smarter and stronger by people, process, and technology.

Industry4WRD aims to pave the way for enhanced productivity, job creation, and high-skilled talent pool in Malaysia's manufacturing sector. Ultimately it is aimed at contributing to economic prosperity and societal well-being. Furthermore, it is also to encourage the development of innovative capacity and capability of the manufacturing sector and related services to create Malaysia's own technologies, products, and services.

With the implementation of Industry4WRD, collaboration between government-industry-academic, and targeted expectation, the industry in Malaysia will remain ahead and competitive in facing the challenges brought by the 4th Industrial Revolution. Agility to adapt to the inevitable Industry 4.0 will drive forward Malaysia's industry and make Malaysia an attractive prospect for advanced technology, innovation, and high value-added industries in the coming years ahead.

Statistics on Manufacturing Sectors in Malaysia

In the early 1970s, Malaysia spearheaded its involvement in manufacturing, a major paradigm shift from agro-based economy to manufacturing-based. According to the Department of Statistic Malaysia's (DOSM) report in August 2020 [1], Malaysia's manufacturing sales in June 2020 stood at MYR116.7 billion, expanding to 30.4% as compared to the previous month. On year-on-year (y-o-y) basis, the sales value rebounded to 4.1% after registering negative growth for three consecutive months due to the COVID-19 pandemic in Malaysia.

Statistic published by DOSM 2016 indicated they were 49,101 manufacturers operating in Malaysia in various sectors:

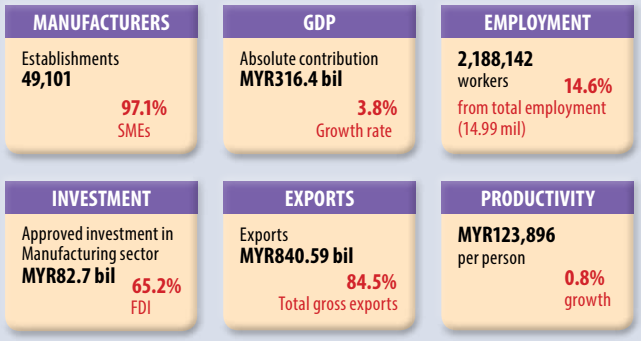
- Electrical and electronic products
- Petroleum, chemical, rubber, and plastic
- Transport equipment and other manufactures
- Wood, furniture, paper products, and printing
- Nonmetallic mineral products, basic metal and fabricated metal products

- Textile, wearing apparel, leather, and footwear
- Food, beverage, and tobacco

GDP for 2019 in the manufacturing sector was recorded at MYR316.4 billion, demonstrating 3.8% growth rate on y-o-y progress. A later report released by DOSM in June 2020 highlighted that the total employment in the Malaysian manufacturing sector was at 2,188,142 employed workers, representing about 14.6% of total work force. Malaysia Investment Development Authority (MIDA) updated that in 2019, the total investment approval for manufacturing-related industry was MYR82.7 billion, with 65.2% of the investment was foreign direct investment (FDI) [2], and the rest were domestic investment. The manufacturing sector also drives export capabilities, as reported by Malaysia External Trade Development Corporation (MATRADE) [3], in 2019 Malaysia achieved MYR840.59 billion of exports, which consists of 84.5% of total gross exports from Malaysia. Figure 5.1 shows the statistic of the manufacturing sector in Malaysia.

FIGURE 5.1

STATISTICS OF MANUFACTURING SECTOR IN MALAYSIA



Source: DOSM, 2016 (Manufacturers); DOSM, 2019 (GDP); DOSM, Jun 2020 (Employment); MIDA, 2019 (Investment); MATRADE, 2019 (Exports); DOSM, May 2020 (Productivity).

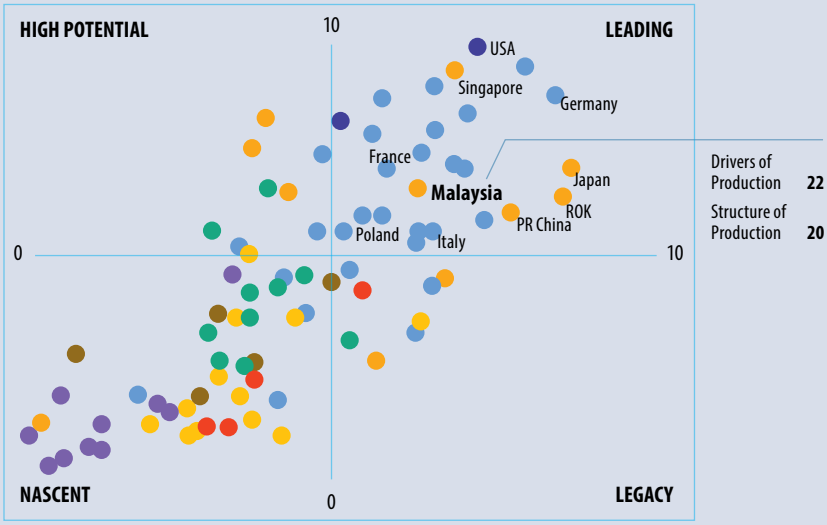
Manufacturing has embarked upon a new age - arising from the convergence of the physical and digital worlds. This new paradigm shift, commonly referred to as Industry 4.0, has the power to transform the creation of products, management of supply chains, and definition of value chains. For companies around the world, Industry 4.0 presents an opportunity to gain new competitive advantage through greater productivity, agility, and speed. For Malaysia in particular, Industry 4.0 creates a host of opportunities to cement Malaysia's role as a global manufacturing hub and to transform its manufacturing base.

In 2018, the World Economic Forum (WEF) [4] ranked Malaysia at the 22nd position in the segment of Drivers of Production and in the 20th spot for Structure of Production. Figure 5.2 shows the readiness for the Future of Production by WEF 2018 Report.

Malaysia's small and medium enterprises (SMEs) are key players in the national economy. Globally, it is the sector that contributes to the economic growth of respective countries. The Asia-Pacific Economic Cooperation (APEC) [5] reported that 97% of establishments and over 50% of employment in the workforce comprises of SMEs in its economies. Meanwhile, the report by the OECD [6] titled 'Enhancing the Contributions of SMEs in a Global and Digitalised Economy' highlighted that SMEs assume a key role in national economies around the world, generating employment, value adding, and contributing to innovation.

FIGURE 5.2

MALAYSIA'S POSITION IN READINESS FOR FUTURE PRODUCT MANUFACTURING



Source: Readiness for the Future of Production Report 2018, WEF.

Based on the National Economic Census 2016 [7]: Profile of Small and Medium Enterprises by the DOSM, SMEs in Malaysia constituted 97.1 of the total business establishments. The majority of the businesses were in the services sector, mainly in wholesale and retail trade, followed by manufacturing, construction, agriculture, and mining and quarrying.

Malaysian Manufacturing SMEs in Facing the Wave of Industry 4.0

Malaysian SMEs are moving from an exploratory stage of facing many challenges to an embracing stage when it comes to Industry 4.0 technologies. The Federation of Malaysian Manufacturers (FMM) notes that small businesses are still finding their way around technologies that are suitable to their needs. "The readiness of the Malaysian manufacturing sector in adopting Industry 4.0 depends on various factors including the nature of business, their products and services and business model. Most multinationals and the larger companies may already be implementing Industry 4.0, however many SMEs could still be at the exploratory stage of understanding and identifying the Industry 4.0 technologies most relevant to their operations," according to FMM [8].

FMM further highlights that while most companies are aware of the need to embrace Industry 4.0, only a small percentage of them have actually installed such technologies. This is according to the 2H2017 FMM-MIER Business Conditions Survey, which looked at the status of adoption and awareness of FMM members toward the nine pillars of Industry 4.0 technologies - industrial Internet of Things (IoT), cloud computing, simulation, additive manufacturing, big data, cybersecurity, vertical and horizontal system integration, augmented reality, and autonomous robots.

The top four technologies which are already in use by SMEs are cybersecurity (35%), cloud computing (27%), industrial IoT (24%), and autonomous robots (7.4%). About 19.3% intend to use robots in their production. From the findings, it shows that Industry 4.0 technology adoption is low. The 3Q2017 SME Survey carried out by the SME Corporation Malaysia stated that 62% of SMEs employees have insufficient knowledge and skills of Industry 4.0. This was reiterated by a 2018 McKinsey study that stated 38% of

SME suppliers and manufacturers have low optimism level. Hence, SMEs need to embrace Industry 4.0 to stay competitive amid the rising cost of doing business.

Government-Academia-Industry Collaborations to Support Malaysian SMEs

SMEs in Malaysia - as in many other countries - face the challenge of competency development, cyber security, and data protection as well as access to funding and capital. The awareness for ICT application is still lacking among the employees. To address this issue, knowledge in ICT application among SMEs' employees need to be strengthened and enhanced in order to embrace the challenges of Industry 4.0. They need to have intensive training to improve their skills that are relevant to the current demand.

The work of the future will be on-demand and the nature of work will mostly be project-based, replacing regular employment, according to the New Straits Times in an article that appeared in January 2018. As such, Malaysia, like other developed countries, must invest in R&D technologies, breaking new grounds in production, service delivery, healthcare, education, and others [9].

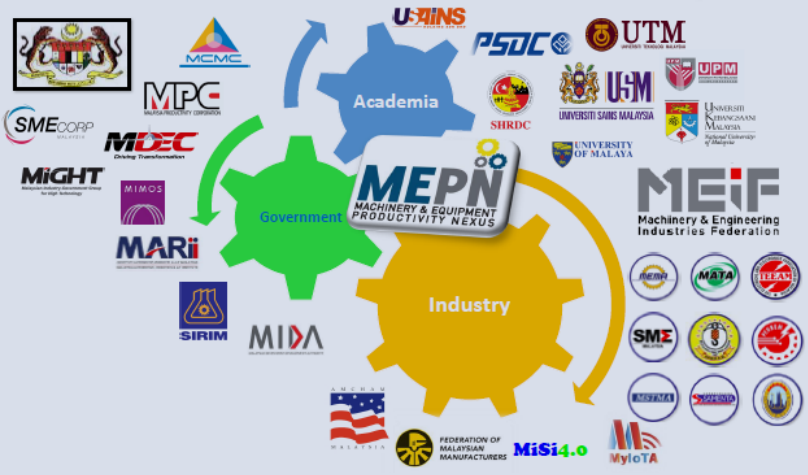
Most of the developed countries have their own initiatives and programs with focused areas to embrace Industry 4.0. For example, the USA have the Industrial Internet (Consortium) and Smart Manufacturing Industry 4.0 platforms [9].

Industry 4.0 is fundamentally reforming the employment landscape and will foster significant changes in the way industrial workers perform their jobs. Entirely new jobs with very different skill requirements will be created while others, especially manual tasks, will become obsolete. The shifting employment landscape has significant implications for industry, education systems, and the government.

A qualified and skilled workforce is indispensable for the introduction and adoption of Industry 4.0. The technical knowledge required is high, and will be recruited primarily from the STEM (science, technology, engineering, and mathematics) subjects. However, enrollment for STEM programs has reduced significantly over the years.

FIGURE 5.3

GOVERNMENT-ACADEMIA-INDUSTRY ENGAGEMENT MODEL IN MALAYSIA



There is an urgent need to create a skilled and diverse workforce with high salary by upskilling the existing labor pool and developing future talent in the manufacturing sector. One of the initiatives of upskilling is the collaboration between USAINS Malaysia and American-Malaysian Chamber of Commerce (AMCHAM) in nurturing talent development for the SMEs. Apart from this, local industry leaders also offer services to upskill targeted SMEs with human capital as a key element in driving impact for productivity.

In Malaysia, the Penang Skills Development Centre (PSDC) was established to spearhead industry skills training and serve as an education center for SMEs. To date, the center has trained over 200,000 participants through more than 10,000 courses related to human capital development and contributed directly to the Malaysian workforce transformation initiatives.

Moving forward, the PSDC has expanded its role and become the Centre of Excellence (CoE) for Industry 4.0 in Penang. Besides PSDC, the Collaborative Research in Engineering, Science & Technology (CREST) is also appointed as a center of excellence for SMEs' talent development that are guided by three working pillars, namely R&D, talent development, and commercialization.

Government Policy Supporting Malaysian SMEs Toward Industry4WRD

The National Policy on Industry 4.0 (Industry4WRD) is a proactive measure undertaken by the Ministry of International Trade and Industry (MITI) to transform the Malaysian manufacturing industry and its related services to be smarter, more systematic, and resilient.

The Malaysian government's vision for the manufacturing sector in the next 10 years is threefold:

- Being a strategic partner for smart manufacturing and related services in the Asia-Pacific
- Primary destination for high-tech industry
- Total solutions provider for advance technology

The National Goals to guide and measure the progress of transformation include:

- Labor productivity growth
- Manufacturing contribution to economy
- Innovation capacity
- High-skilled jobs

The quantified factors that need to be optimized in a balanced manner are:

i) People/Organization

Focuses on the people or entire organizations by emphasising on strategies toward having a suitable set of workforce. This can be achieved through the development of the required human capital and sustainable transformation activities with regards to organizational strategies, collaboration, and governance.

ii) Process

Focuses on the management system involved in running business operations, supply chain, and product life cycle. This is done by emphasising on smart and strategic public-private partnerships, security, sustainability, and product cocreation.

iii) Technology

Focuses on the application of intelligent, connected, and automated technologies that is measured at the three different layers of business - shop floor, facilities, and enterprise.

The government created specific enablers to determine the strategies, policies, and action plans, as the following:

- **Funding** - Funding and outcome-based incentives
- **Infrastructure** - Enabling ecosystem and efficient digital infrastructure
- **Regulations** - Regulatory framework and industry adoption
- **Skills & talents** - Upskilling existing and producing future talents
- **Technology** - Access to smart technologies

Three strategies have been initiated as below:

Strategy 1
Increase awareness of the need, benefits, and opportunities of Industry 4.0 technologies and business process among manufacturing firms.

Strategy 2
Create a platform and mechanism to help manufacturing and related services firms, especially SMEs, to assess and develop their Industry 4.0 capabilities.

Strategy 3
Improve data integrity, standards, sharing, and security to facilitate seamless integration of manufacturing value chains and to support intra-ministerial coordination for effective Industry 4.0 programs.

SUCCESSFUL BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

Case Study 1: Electronics Manufacturing Services (EMS) Company

Company Background

This company is an EMS provider. Since 1999, they have been providing manufacturing services and technical support to various sectors, such as networking and communications, instrumentation, consumer products, medical devices, and automotive. The company's vision is to serve various industrial sectors by providing an alternative choice to the prospect. Services provided by this company include

all kinds of high-speed surface-mount technology (SMT), chip on flex/board (COB), final assembly (box build), precision plastic molding, and final testing services.

The company firmly believes that long-term customer satisfaction is the cornerstone of their success. To continue meeting the changing needs of their valued customers, this company is committed to creating value that increases customer competitiveness through a World-Class Manufacturing Excellence solution that delivers superior quality and service.

By continuing to deepen their knowledge, develop innovative solutions, and advance their capabilities, they wish to help global industry leaders to increase their efficiency and stay ahead of the competition.

Strategy Mapping with Balance Scorecard (BSC)

Strategically, this company has developed their focus objectives for manufacturing transformation. From the concept of BSC, this company has developed their strategic objectives from four perspectives and integrate into one strategic map. Table 5.1 shows the strategic objectives with BSC mapping. The Strategic Objectives are:

- Financial perspective
- Customer perspective (including adoption of technology)
- Internal process perspective
- Learning and growth perspective

TABLE 5.1

BSC STRATEGY MAPPING FOR EMS COMPANY

Strategic Objectives	Driving Results Through Operational Excellence			Strategic Measurements	
				(Lag Indicators)	(Lead Indicators)
Financial Perspective	1.1 Broaden revenue mix	1.2 Improve ROI	1.3 Lean manufacturing	• Revenue growth • ROI • Cost reduction	• Revenue mix
Customer Perspective	2.1 Increase customers' satisfaction in quality & productivity	2.2 Improve satisfaction on supply chain	2.3 Value-added and value creation services, including intelligence in technology	• Customer retention • Customer introduction or influence customer	• Strong trust for further project partnerships • Best supplier & vendor reward
Internal Process Perspective	3.1 Understand customers' expectations	3.2 Embedded innovation solutions	3.3 Digitalization transformation	• New product revenue	• Digital data driven • Shorten product development cycle
Learning & Growth Perspective	4.1 Develop strategic skills	4.2 Leadership development	4.3 Talent development	• Revenue per employee • Employee satisfaction	• Strategic job coverage ratio • Personal goal alignment (%)

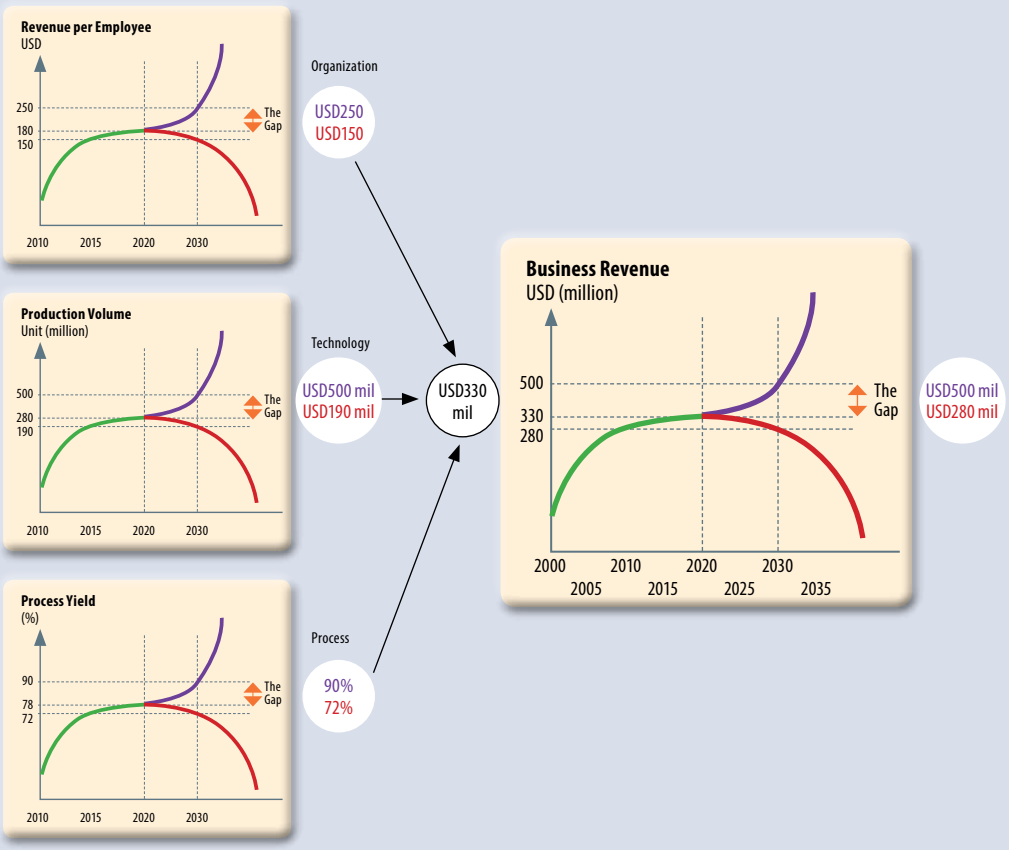
This company plans to go public listed upon achieving business revenue of above USD500 million. Currently, they have achieved USD330 million. In order to achieve the goal for initial public offering (IPO), the company has decided to focus on financial perspective in revenue mix strategy.

Strategy Dynamics on Case Study 1

The company has set its goal to achieve business revenue of USD500 million by 2030 in order to go public. Figure 5.4 shows the strategy dynamics model for this case study.

FIGURE 5.4

STRATEGY DYNAMICS FOR CASE STUDY 1 - EMS MANUFACTURER



In 2019, the company achieved business revenue of USD330 million. Despite facing tough challenges of the COVID-19 outbreak in 2020, the company's aim to achieve a business revenue of USD500 million by 2030 remains the target, and it utilizes the Strategy Dynamics model to plan its way forward.

The company is left with little choice - to either move up the business revenue or operate as usual where their business competitor may overtake them by 2035.

Its success is driven by three core pillars - organization (talents), process, and technology. The strength in these three core pillars is already proven as it allowed them to achieve a business revenue of USD330

million after 20 years of operations. Based on their core pillars, the company further strategized on what they needed to do to achieve business revenue of USD500 million.

i) Process pillar

The company's process yield was at an average of about 78%–85%. In order to achieve breakthrough, the company has planned to improve the process yield to at least 90% and above. To achieve the goal, the company saw the need to invest as a way to improve the process. The areas covered under Process improvement include operations, product customization, and supply chain management, as shown in Table 5.2.

TABLE 5.2

SCOPE OF PROCESS PILLAR

Process	Operations	• Digitization and Industry 4.0
		• Vertical integration
	Product Development	• Customization
		• Product life cycle
	Supply Chain	• Real-time integration

The company had already started investing in Industry 4.0 technologies since 2017 due to the demand from their customers who are based in Germany. In the earlier shop floor, the SMT production lines had five workers for each line. After adopting and implementing Industry 4.0 technologies, there were only five employees in charge of over 20 SMT productions lines. The rest of the human resource were diverted to work in the Industry 4.0 Control Centre and cross-trained to data analytics and other critical tasks. Figure 5.5 shows the company environment of Industry 4.0 Control Centre.

FIGURE 5.5

ESTABLISHED INDUSTRY 4.0 CONTROL CENTRE FOR PROCESS (PRODUCTIVITY & QUALITY) IMPROVEMENT

ii) Technology pillar

This company provides EMS manufacturing services to multinational companies (MNCs), thus enhanced technological capabilities is a strong driving factor to ensure customers satisfaction. Technology capabilities is also the differentiator for them to leapfrog from their competitors. Table 5.3 shows the details scope of Technology pillar.

TABLE 5.3

SCOPE OF TECHNOLOGY PILLAR

Technology	Automation	• Enterprise, shop floor, and facility automation
	Intelligence	• Enterprise, shop floor, and facility intelligence
		• Data analysis
		• Self-optimization
	Connectivity	• Enterprise, shop floor and facility connectivity
		• Data security

This company has implemented some Industry 4.0 elements in the process manufacturing area with full automation production line. In order for them to realize the planned business revenue of USD500 million by 2030, they have decided to invest in this pillar in 2020–22. The company's Industry 4.0 task force committee has strategized to improve data analysis and full connectivity in enterprise, shop floor, and facility areas which are aligned with the 5G adoption in Malaysia.

The Industry 4.0 task force committee also highlighted that they will focus on manufacturing self-optimization and data security by 2023–25. This means that by 2025, the company is planning to achieve 80% of Industry 4.0 capabilities.

iii) Organization pillar

This company was established for more than 20 years and their Industry 4.0 transformation journey began in 2015. This is due to the fact that most of their Germany-based customers were requesting them to align with Industry 4.0 practices that have already begun in their country. The company leadership team had called to establish an Industry 4.0 task force committee to study the potential of company's Industry 4.0 transformation and to incorporate it into their business strategy. Table 5.4 shows the scope of Organization pillar in better detail.

TABLE 5.4

SCOPE OF ORGANIZATION PILLAR

Organization	Leadership and talent development	• Talent development
		• Leadership - digitization readiness
	Business and strategy	• Digital business transformation
		• Strategy digitization

iv) Risk assessment

The company has conducted risk assessment of 'doing nothing' and not taking any action as requested by their main customers (Germany based) to adopt Industry 4.0 transformation. The potential implications were as following:

◊ Potential loss of major customers
- Germany-based customers contribute 80% to their business revenue for 15 years

◊ Unable to compete with competitors from other ASEAN region (Vietnam, Philippines, and Thailand), especially on production cost
- Their business revenue may sink to USD280 million and further down in the next few short years

◊ The current high-mixed low-volume production line was only possible to leapfrog with high technology intervention
- From value-added to value creation

The company's decision to move forward with full implementation of Industry 4.0 was already on the right track. They gained more business and were meeting key customers' expectation, especially those based in Germany. Their digital transformation journey had started and the company needs to stay focused and complete the Industry 4.0 transformation in accordance to the plans. It is expected that by 2025, the business operation review will show more significant results and improvements from the Industry 4.0 transformation exercise.

Case Study 2: Manufacturer of Glove Industry

Company Background

Established in 1991 and headquartered in Malaysia, this company is the world's largest manufacturer of rubber gloves. What started as a local business enterprise with one factory and one-glove production line has today captured 26% of the world market share for rubber gloves. The company has manufacturing operations in Malaysia, Thailand, and China. It also has marketing offices in these countries as well as the USA, Germany, and Brazil, and exports to over 2,000 customers in 195 countries worldwide. The company currently operates with 46 factories, 722 productions lines, production capacity at 85.2 billion gloves per annum, market capitalization of MYR75.8 billion (as at 21 August 2020), and business revenue MYR2.4 billion (as 19 March 2020).

Listed on the Malaysian bourse (2001) and Mainboard of the Singapore Exchange (2016), this company has demonstrated steady growth with a compound annual growth rate (CAGR) of 21.7% for revenue and 19% for profit after tax (PAT) over the past 18 years. It is also a component stock of the MSCI Global Standard Index, FTSE Bursa Malaysia KLCI Index, FBM Top 100 Index, FBM Emas Index, FBM Hijrah Syariah Index, FBM Emas Syariah Index, FTSE4Good Bursa Malaysia Index, and the Dow Jones Sustainability Index (DJSI) for Emerging Markets.

The company offers a comprehensive product range, which now includes a non-glove segment comprising condoms, face masks, dental dams, and exercise bands, fulfilling demands in both the healthcare and non-healthcare segment. In line with its commitment to sustainability, this company will continue to level up its practices in the environmental, social, and governance (ESG) space, particularly in terms of labor practices.

The company's outstanding achievements and global recognition are credited largely to its founder's vision and driving force, who within a short span of time, has built the company into a resounding global success.

With the help of its 20,000 employees, this company continues to produce high quality gloves at an efficient low cost in line with its time-tested Business Direction. Not content to rest on its laurels, this company has set its sights on higher aspirations, which include increasing its world market share to 30%

by end 2020 and becoming a Fortune Global 500 Company by 2040. Accordingly, it continues to expand its business scope and to be on the lookout for mergers and acquisitions (M&A) opportunities in similar and related industries.

Reported by Business Today on 11 June 2020, this company's financial results for the third quarter ended 31 May 2020 attained a sales revenue of MYR1.7 billion, making it the company's highest ever quarterly revenue. The hike was an increase of 42% compared with its 3QFY19 and a 37% hike versus 2QFY2020.

The company's profit before tax (PBT) came in at MYR422 million, staging a triple-digit gain of 413% and 224%, year-on-year and quarter-on-quarter, respectively. As for PAT, this company recorded an impressive MYR350 million, an increase of 365% year-on-year and 202% quarter-on-quarter, which at the nine-month mark made up 95% of FY2019's full year achievement.

Following the growth of its organic expression, this company has secured its position as the world's largest manufacturer of nitrile gloves. This comes after it secured its position as the world's largest manufacturer of natural rubber gloves and surgical gloves.

The Group's 9MFY2020 performance recorded MYR4.1 billion in sales revenue while PBT was MYR677.8 million. PAT was MYR577.8 million, rising 97% from the corresponding period last year, and far exceeds the total net profit for the full financial year 2019 by 57%.

Monthly sales orders went up by some 180%, resulting in long lead times, which went up from 40 days to around 400 days, whereby orders placed at that current period would only be delivered over a year later.

Further, the Group's utilization rate rose from a pre-COVID-19 level of 85% to above 95% in 3QFY2020, resulting in greater efficiency and economies of scale. Additional capacity which came onstream in 3QFY2020 also enabled the Group to meet demand growth while upward revisions in average selling prices (ASPs) in line with prevailing market prices were also affected.

With the world facing the COVID-19 pandemic in full scale, the company worked hard in producing the essential item for its global clients.

The company emerged the best performing stock on both the Kuala Lumpur Composite Index (KLCI) and the Straits Times Index (STI), having seen its share price increase by 263% and 268%, year-to-date, respectively. As at 10 June 2020, it ranked the sixth largest company on Bursa Malaysia and the 12th largest company on SGX in terms of market capitalization, placing it among the elite Top 15 companies on both bourses.

The company has also earmarked MYR3 billion for CAPEX to build 450 new lines, creating new capacity of 60 billion pieces of gloves from CY2020 to CY2026. Additionally, as at 31 May 2020, the company's financial position improved significantly, with a net cash position of MYR279 million compared with net borrowings in 2QFY2020. This has enabled the company to fund CAPEX requirements.

The global glove demand is expected to grow from a pre-COVID-19 level of 8% to 10% per annum to 12% to 15% per annum post-COVID-19, on the back of increased usage in both the medical and nonmedical sectors as well as heightened awareness.

Strategy Mapping with BSC

Strategically, this company has developed their focus objectives for manufacturing transformation. From the concept of BSC, this company has developed their strategies objectives from four perspectives and integrate into one strategic map.

- Financial perspective
- Customer perspective (including adoption of technology)
- Internal process perspective
- Learning and growth perspective

TABLE 5.5

BSC STRATEGY MAPPING FOR GLOVE COMPANY

Strategic Objectives	Think Big, Dream Big, Do Big, Achieve Big			Strategic Measurements	
				(Lag Indicators)	(Lead Indicators)
Financial Perspective	1.1 Broaden revenue mix	1.2 Improve ROI	1.3 Lean manufacturing	• Revenue growth • ROI • Cost reduction	• Revenue mix
Customer Perspective	2.1 Increase customers' satisfaction in quality & productivity	2.2 Improve satisfaction on supply chain	2.3 Value creation services, including fully vertical integration in Process	• Customer retention • Customer introduction or influence customer	• Strong trust for further project partnerships • Best supplier & vendor reward
Internal Process Perspective	3.1 Understand customers' expectations	3.2 Embedded innovation solutions	3.3 Digitalization transformation	• New product revenue	• Digital data driven • Customized product development
Learning & Growth Perspective	4.1 Develop strategic skills	4.2 Leadership development	4.3 Talent development	• Revenue per employee • Employee satisfaction	• Strategic job coverage ratio • Personal goal alignment (%)

This manufacturer plans to become a Fortune 500 company by 2040. Currently they have achieved their business revenue of about MYR4.8 billion or USD1.1 billion. Today they are the biggest supplier of gloves to the world market. In order to achieve their goal to be included in the global top 500 companies, this company has decided to focus on the financial perspective in revenue mix, cost reduction (tiny gain theory), and optimize process control with digital transformation.

Strategy Dynamics in Case Study 2

In the manufacturer's aspiration to be part of a Fortune 500 company by 2040, business revenue has to be at USD350 billion, which is 30 times from current business revenue. For perspective, Shanxi Jincheng Anthracite Coal Mining Group ranked 500th position in year 2020 Fortune 500 with a business revenue of USD25.4 billion (set as baseline revenue).

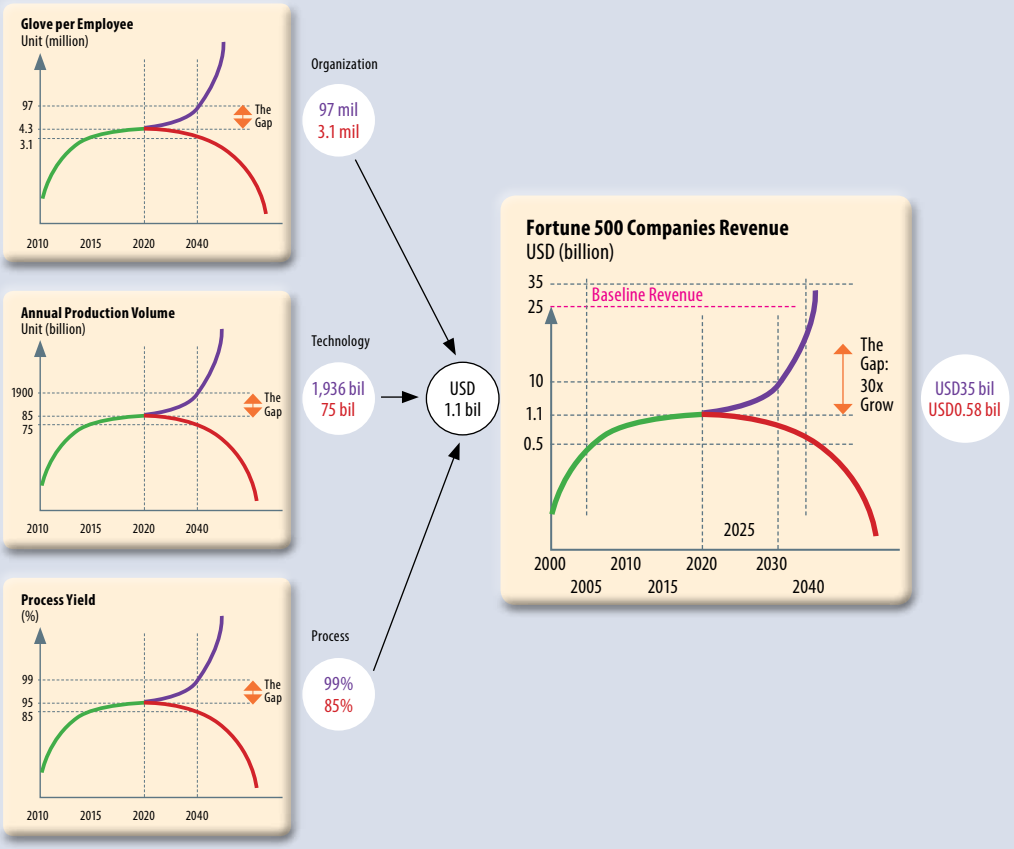
The major driving factors for Industry 4.0 transformation are the Process and Technology pillars. Organization is still an important pillar, however the current workforce majority of its 20,000 employees are foreign workers. As the Malaysian government has tightened the foreign labor policy, moving forward, the manufacturer can only rely on Process and Technology to continue their business operations.

The executive chairman of the company has set the direction for this company to move forward in the next 20 years. However they can only achieve their key performance index by multiplying business

revenue by 30 times from their current business. This is a very challenging and uphill task for the entire team. Figure 5.6 shows the strategy dynamics model for this case study.

FIGURE 5.6

STRATEGY DYNAMICS FOR CASE STUDY 2 - GLOVE MANUFACTURER



i) Process pillar

Since the COVID-19 outbreak, this company's production loading has increased from 85% to 95%. This loading increment needs to align with the process yield improvement. The current yield of 95% can be further improved to 99%; a benchmarking of the semiconductor industry production yield requirement. Process yield is determined by operations, product development, and supply chain (see Table 5.6).

TABLE 5.6

SCOPE OF PROCESS PILLAR FOR GLOVE MANUFACTURER

Process	Operations	• Digitization and Industry 4.0
		• Vertical integration
	Product Development	• Customization
		• Product life cycle
	Supply Chain	• Real-time integration

In order to optimize the Process operations, a vertical integration is planned to streamline the manufacturing process, and will directly improve the process yield while handling the 10% increase of production loading. The entire process recipe needs to be standardized and centralized in order for it to be utilized across the 722 production lines.

ii) Technology pillar

This company looks into investing in another new 450 production lines to meet the market demand with another 60 billion pieces of gloves from 2020–26. Technology will be used to optimize the manufacturing process and improve productivity and quality. Gloves industry has always been classified as a labor-intensive industry in Malaysia. In order to reduce the dependency of foreign labors to work in this company, the company's executive chairman and top management have decided to invest in manufacturing technology - including Industry 4.0 as part of the digital transformation program toward 2040. Table 5.7 shows the scope of Technology pillar in the glove industry.

TABLE 5.7

SCOPE OF TECHNOLOGY PILLAR IN GLOVE INDUSTRY

Technology	Automation	• Enterprise, shop floor, and facility automation
	Intelligence	• Enterprise, shop floor, and facility intelligence
		• Data analysis
		• Self-optimization
	Connectivity	• Enterprise, shop floor, and facility connectivity
		• Data security

iii) Automation

In order to reduce the dependency on foreign labor, process automation is the immediate solution to solve labor shortage issues. However, investment for automation or robotics can be too expensive or needs a high capital investment. Thus the knowledge of calculating the return of investment (ROI) is critical. This company has engaged Industry 4.0 system integrator to study the digital transformation in stages, plant to plant, and/or by state or country.

iv) Intelligence

As part of the company's strategy to be in the Fortune 500 business community by 2040, the manufacturing process must be embedded with intelligence technology, such as data analytics (machine learning and deep learning) and process self-optimization as technology differentiator from competitors. The company will prepare the talents with data analysis capabilities when they start to implement the plans for the new 450 production lines.

v) Connectivity

The company will begin with enterprise, shop floor, and facility level of connectivity and strategic wireless communication system, such as LPWAN (low power wide area network), LoRA, NBIoT, or Sigfox, while integration to WiFi6 (IEEE802.11.ax) for some specific solutions. The manufacturer is also waiting for the 5G deployment nationwide in 2020–22.

vi) Risk assessment

The company has conducted risk assessment of 'doing nothing' and not taking any action in adopting Industry 4.0 transformation. The potential implications are as follows:

◊ Potential loss opportunity to become a Fortune 500 company by 2040
- Without industry 4.0 transformation, it can hardly increase the business revenue by 30 times within 20 years

◊ Unable to compete with other competitors from Malaysia and the ASEAN region (Indonesia and Thailand), especially when competing on production cost
- Their business revenue may sink down to USD500 million and further down in next few years, potentially due to price war

◊ COVID-19 pandemic - strong demand for gloves will decrease once vaccine is found
- Fast response to capture business opportunities is critical

This company decided to move forward with the full implementation of Industry 4.0 in their upcoming 450 production lines and upgrade the existing 722 production lines in stages. Due to the government implementing Movement Control Order (MCO) from 18 March–31 December 2020, many foreign workers were prohibited from entering the country or given limited permit approval to work. Thus the company has to plan ahead for the worst-case scenario, and substitute Industry 4.0 as a mitigation plan to overcome production backlog. This is more so as the demand of medical gloves was overwhelming during the COVID-19 pandemic.

The company's journey of digital transformation has begun. They need to stay focused and complete the Industry 4.0 transformation as planned. It is expected that by 2040, the manufacturer will make a business revenue 30 times than what it is today, and they will put their company name in Fortune 500.

Case Study 3: Machinery and Equipment Fabrication Company

Company Background

This company started out in 2002, occupying a small shop lot in Negeri Sembilan, Malaysia. It slowly grew to occupy three adjacent units before moving into its current headquarters in December 2012.

In the beginning, it started off by providing technical support to the semiconductor industry for test handlers before moving into module design and production. The first in-house designed, full-fledged handler was introduced in 2008. Since then, the company has designed and produced a wide range of turret and pick-and-place solutions for its customers all over the world. Their current workforce is 125; about 85% of their workforce have engineering background. Figure 5.6 shows the company's operation shop floor that fabricates machinery and equipment (M&E).

This company has an established track record as an original equipment manufacturer (OEM) and original design manufacturer (ODM) in the manufacturing automation industry. Its highly-skilled team of design engineers and production crew are capable of providing contract manufacturing services as well as develop turnkey systems for large-scale manufacturing operations. The product range of 200/250/300/400 turret-based handlers are used by some of the largest consumer electronics companies in the world.

FIGURE 5.7

OPERATION SHOP FLOOR OF M&E COMPANY FOR SEMICONDUCTOR COMPANY

Other platforms include linear (Pick and Place) and wafer-based handlers, including highly advanced high-speed wafer to tape sorter solutions. This company has also produced customized manufacturing automation solutions, including those for medical and other non-semiconductor industries.

The company now has direct sales and technical support presence in several countries in Asia (Thailand, Philippines, PR China, Republic of China, and Japan) and also in the USA. As the global high-tech consumer goods and semiconductor industries continue to grow, this company will be there to empower its customers through creative innovation and exceptional performance, staying true to its tagline, "Embracing Innovation, Engineering Perfection."

Strategy Mapping with BSC

Strategically, this company has developed their focus objectives for manufacturing transformation. From the concept of BSC, this company has charted their strategies objectives from four perspectives and integrated into one strategic map.

- Financial perspective
- Customer perspective (including adoption of technology)
- Internal process perspective
- Learning and growth perspective

TABLE 5.8

BSC STRATEGY MAPPING FOR M&E FABRICATION COMPANY

Strategic Objectives	Embracing Innovation, Engineering Perfection			Strategic Measurements	
				(Lag Indicators)	(Lead Indicators)
Financial Perspective	1.1 Broaden revenue mix	1.2 Improve ROI	1.3 Lean manufacturing	• Revenue growth • ROI • Cost reduction	• Revenue mix
Customer Perspective	2.1 Increase customers' satisfaction in quality & productivity	2.2 Improve satisfaction on supply chain	2.3 Value-added and value creation services, including intelligence in technology	• Customer retention • Customer introduction or influence customer	• Strong trust for further project partnerships • Best supplier & vendor reward
Internal Process Perspective	3.1 Understand customers' expectations	3.2 Embedded innovation solutions	3.3 Digitalization transformation	• New product revenue	• Digital data driven • Shorten product development cycle
Learning & Growth Perspective	4.1 Develop strategic skills	4.2 Leadership development	4.3 Talent development	• Revenue per employee • Employee satisfaction	• Strategic job coverage ratio • Personal goal alignment (%)

This company plans to go public by 2025. Currently they have achieved their business revenue of about USD230 million. Today they are one of the top 10 best M&E turnkey companies in Malaysia. In order to achieve their goal to become top five by 2025 means the company's business revenue must be above MYR1.94 billion (USD450 million). This company has decided to focus on the financial perspective in revenue mix, internal process with new product revenue, and digital data driven for their new product development.

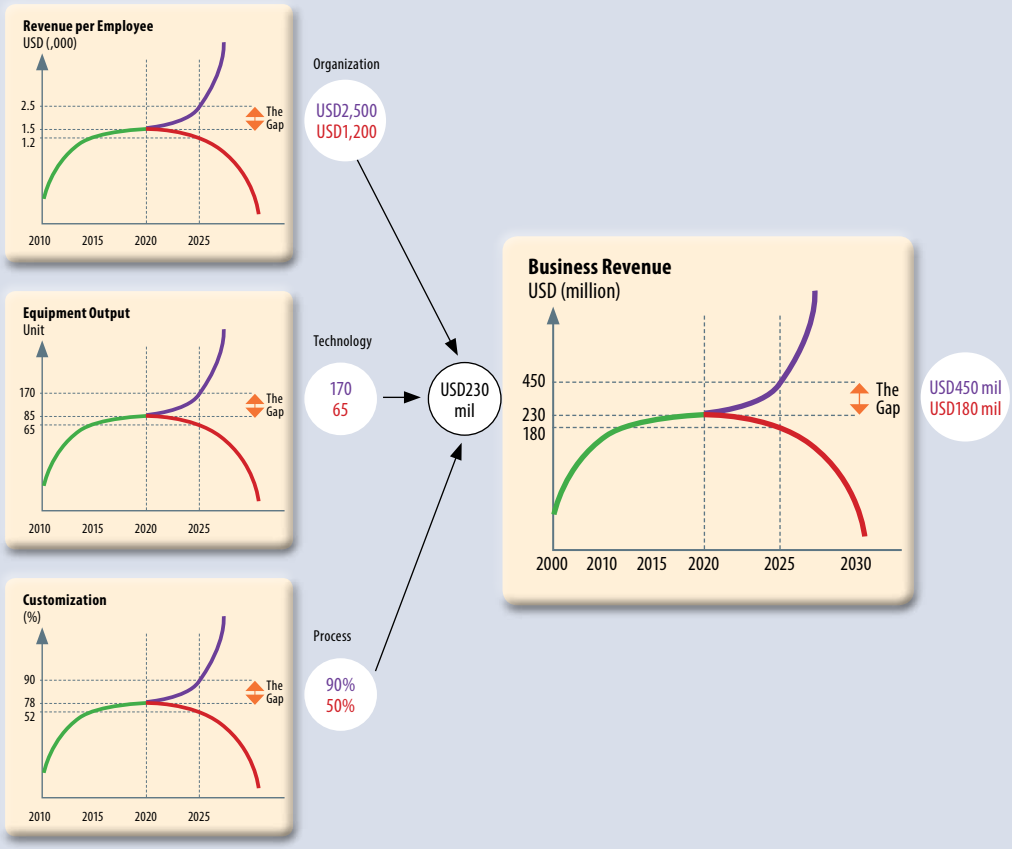
Strategy Dynamics in Case Study 3

With the company's goal firmly in place, which is hitting a business revenue of USD450 million (double from the current business revenue) and to be public listed by 2025, it has embarked on an Industry 4.0 journey. It identifies the best practices to be adopted as to achieve their business goal in short coming years.

The major driving factors of Industry 4.0 transformation for this company is the Organization pillar and supported by the Process and Technology pillars. Turnkey design and fabrication business are always critical of resource issues while the talents are the most valuable asset to the organization. This company has a mixture of experienced leaders and a big number of young engineers. Most of the leaders have been with the company for more than 15 years. Figure 5.8 shows the Strategic Dynamic for this turnkey M&E fabricator.

FIGURE 5.8

STRATEGY DYNAMICS FOR CASE STUDY 3 - TURNKEY M&E FABRICATOR



i) Organization pillar

Based on their current revenue per employee, the company needs to increase this from the current USD1,500 to USD2,500. The gap is USD1,000. The company has invested in talent development through overseas technical training and provides great retention package to the employees. This company understands that their most important asset in M&E turnkey (Design and Fabrication) is the talent they have in the organization. Their in-house talent have great innovation ideas to design the next generation equipment for the semiconductor industry which will be the game changer to this company.

The company founder who is also the executive director focuses on digital transformation in their business and strategy. He has invested in new ICT facilities to digitize all the manual process. Engineering drawing with the latest design software, such as SolidWorks, AutoCAD, and Pro-Engineer are used to replace previous manual engineering drawing. This investment will increase employees' productivity and creativity, and will directly impact revenue per employee in the next three to five years.

In order to retain their talents and attract the best young talents to join them, the company has established some great work-life balance programs. Company overseas retreats are organized

annually and special financial support is provided for in-house engineers who wish to purchase their first home near or within 5 km radius from the company.

ii) Process pillar

In this area, the most important engagement with customers is in design customization. The design complexity relates directly to design customization - more complex designs will increase more turnkey design revenue. This company encourages their design engineers to work closely with their customers, allowing customers to be involved in the M&E design. At present, customized designs contribute to 78% of total works. The company has set the goal to further involve their customers in customized design to 90% in next five years.

The company has operated for more than 18 years since their establishment in 2002. They are aware that customers who participate in turnkey design activities will remain with them for many years. The working relationship is more like a strategic partner, rather than just normal business supply-chain relationship.

This company also has great business partnership with a few USA-based customers where their equipment are mainly custom-designed and used in very high-tech industries in the USA. The trust that they have built up with their customers there is the success criteria to continue their premium business. Table 5.9 shows the important three core pillar in M&E turnkey (design & fabrication) services.

TABLE 5.9

SCOPE OF THREE CORE PILLARS IN M&E TURNKEY (DESIGN & FABRICATION)

Organization	Leadership and talent development	1. Talents development
		2. Leadership - digitization readiness
	Business and strategy	3. Digital business transformation
		4. Strategy digitization
Process	Operations	5. Digitization and Industry 4.0
		6. Vertical integration
	Product Development	7. Customization
		8. Product life cycle
	Supply Chain	9. Real-time integration
Technology	Automation	10. Enterprise, shop floor, and facility automation
	Intelligence	11. Enterprise, shop floor, and facility intelligence
		12. Data analysis
		13. Self-optimization
	Connectivity	14. Enterprise, shop floor, and facility connectivity
		15. Data security

Due to the nature of business, this company also needs knowledge and experience to manage the product life cycle together with their customers. Due to the changes of technology node in the semiconductor industry, the product life cycle for this M&E turnkey design must be aligned strategically in order to gain optimum business opportunities with premium margin.

iii) Technology pillar

This is a critical pillar for this company that designs next-generation semiconductor equipment. With Industry 4.0 technologies being implemented in semiconductor manufacturing, most of the equipment must fulfil or comply with Industry 4.0 requirements. The new equipment that they design must be fully automated, embedded with intelligence, and open connectivity capabilities.

Such equipment's main differentiators are the secret of embedded intelligence, where the equipment that they design must have the capabilities of data analytics (machine learning or deep learning) from cloud to edge or edge to cloud, vision inspection, and communication protocol in semiconductor industry. Equipment with self-optimization capabilities is a game changer or technology leapfrog verses against their business competitor. Optimization can only happen when the equipment collect sufficient process data.

This company has invested in their engineers to learn about data analytics, especially in deep learning. Thus they have developed their own algorithms and source codes to increase equipment intelligence (prediction and prescription), and mapping with augmented reality (AR) and virtual reality (VR) technology adoption.

iv) Risk assessment

The company has conducted risk assessment of 'doing nothing' and not taking any action of adopting Industry 4.0 transformation. The potential implications are:

◊ Potential loss of opportunity to become Top Five Turnkey M&E in Malaysia
- Without Industry 4.0 transformation, increasing business revenue to twice the amount within five years may be almost impossible

◊ Unable to compete with competitors within Malaysia
- Most of the M&E turnkey (design & fabrication) services have started the digitization journey, making the business lose out revenue

◊ Low-customer engagement for product customization
- Higher customization percentage will generate more premium revenue

◊ Talent retention - unable to keep talents who wish to embark on the latest technology
- Revenue per employee will only increase when employees are equipped with the latest technology and know-how, such as data analytics (machine leaning, deep learning, algorithms development - Python & C#), mixed reality (AR + VR), 5G connectivity (including LPWAN, WiFi6, etc.), and more

This company will continue to move forward with full implementation of Industry 4.0 in their current plant and encourage their customers for customized M&E designs with the latest embedded intelligence. Perhaps within the next five years, the company will be public listed and become top five of turnkey (design & fabrication) in Malaysia as well as be aligned with big names, such as ViTrox, SRM, Mi-Equipment, Greatech, and PentaMaster.

CONCLUSION AND RECOMMENDATIONS

Based on the three Malaysian case studies, it shows that the journey of digital transformation has just begun in the country. The adoption of Industry 4.0 in the manufacturing sector is still at the very early stage. Many manufacturers, especially SMEs still do not fully understand the power of digitalization in manufacturing. However, the government is a strong supporter of digital transformation for all business sectors that include manufacturing and servicing industry.

It is too early to measure the total impact of the Industry 4.0 transformation in Malaysia. The industry has just newly adopted digital transformation, especially the manufacturing sector. Manufacturing process data are just collected and is still insufficient to be used for data analytics - deep learning, but industry players agree that digital transformation journey has started timely.

Some recommendations to the Malaysia government and industry associations:

i) Prioritize Industry 4.0 transformation implementation by stages with priorities and focus should be given to labor-intensive industries. For example, glove manufacturing, garment manufacturing, etc.

ii) Digitalize, simplify, and accelerate the matching grant application process. The current pace of approval process is unable to match industry's time sensitivity to the market. The digitalization grant should be managed by a single dedicated government agency and not distributed through multiple agencies, as is the current practice

iii) Local financial institution support, such as banks, credit corporations, etc., should provide more flexible financial loans to SMEs to encourage more SMEs to adopt digital transformation

iv) Government agencies can engage and collaborate with industry associations to co-organize Industry 4.0 Transformation programs. Coaching or mentoring may be required to support the SMEs to begin their digital transformation journey

v) Establish regional public and/or private Industry 4.0 Center of Excellence (CoE) as a platform of technical reference and demonstration. CoEs are able to share success stories, provide support, and promote adoption of Industry 4.0 transformation

The journey of digital transformation will be long and ongoing. Full commitment is needed from both government and private institutions to drive Industry 4.0 transformation. Productivity improvement, reduction of waste materials, and optimization of human resources are some of the positive outputs that can be measured once digital transformation has taken place.

CHAPTER 6

THAILAND

INTRODUCTION ON INDUSTRY 4.0 APPLICATION AND CONTEXT CONDITIONS

Manufacturing Sector in Thailand and Manufacturing SME Wave of Industrialization

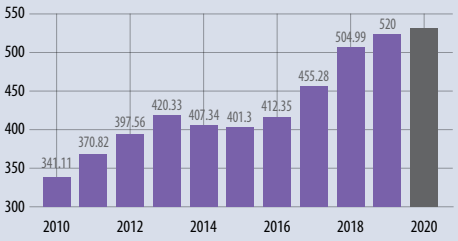
Thailand has a labor force of 38.9 million people out of its 69.4 million population. Its economy is heavily based on agriculture, which contributes 8.1% of the GDP and employs 30.4% of the active population. The country is the largest rubber producer in the world and is one of the leading producers and exporters of rice. Among its major crops are sugar, corn, jute, cotton, and tobacco. Fishing constitutes an important activity as Thailand is a major exporter of farmed shrimp. However, agriculture's contribution to the GDP is declining while the exports of goods and services have increased.

The manufacturing sector accounts for 34.9% of the GDP and is well-diversified, employing 23.4% of the active population. The main Thai industries are electronics, steel, and automotive. Thailand is an assembly hub for international car brands. Electrical components and appliances, computers, cement, furniture, and plastic products are also important sectors. The textile sector employs less than a quarter of the active population and is no longer dynamic as the tourism sector, which has become the main source of foreign currency.

FIGURE 6.1

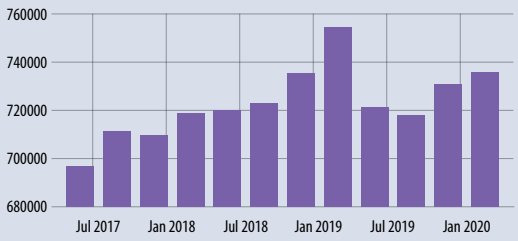
THAILAND GDP

(a) GDP of Thailand (unit = USD billion)



Actual	Previous	Highest	Lowest
520.00	504.99	520.00	2.76
Dates	Unit	Frequency	
1960–2019	USD billion	Yearly	Current USD

(b) GDP from Manufacturing in Thailand (unit = THB million)



Actual	Previous	Highest	Lowest	
734,995	728,890	755,552	267,937	
Dates	Unit	Frequency		
1993–2020	THB million	Quarterly	Constant Prices, SA	2002

Source: Trading Economics, Thailand GDP (https://tradingeconomics.com/thailand/gdp).

The GDP in Thailand was worth USD520 billion in 2019, according to the official data from the World Bank and projections from Trading Economics [1]. The GDP value of Thailand represents 0.43% of the world economy. Also, GDP from manufacturing in Thailand increased from THB728,890 million in Q4 2019 to THB734,995 million in Q1 2020.

Small and medium enterprises (SMEs) play a significant role in the Thai economy. The previous definition of Thai SMEs - in use for 16 years - was categorized by the number of employees and the value of fixed assets. In 2019, the SME promotion committee redefined SMEs to include micro, small, and medium-scale enterprises and has asked the government to help directly the very small-scale SMEs. The size of Thai SMEs is now categorized by the number of employees and annual revenue, as presented in Table 1 [2]. Therefore, all statistical data before 2019 must be reorganized alongside the new definition.

TABLE 6.1

NEW DEFINITION OF SMES IN THAILAND, BEGINNING 26 NOVEMBER 2019

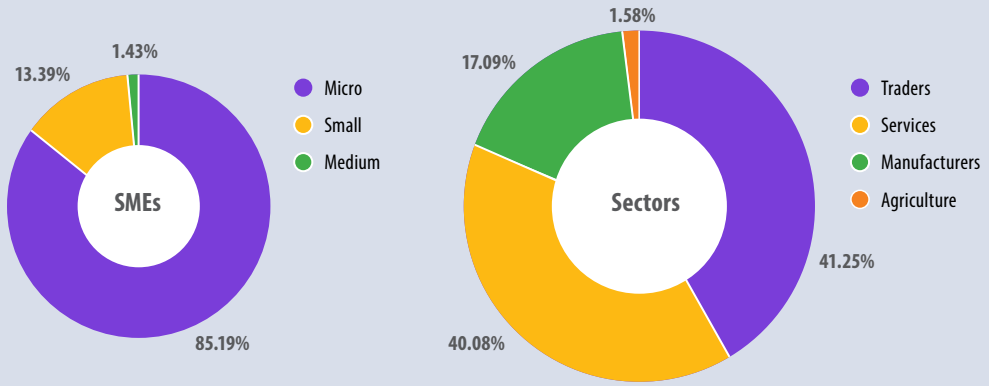
Enterprises	Manufacturers		Trades and Services	
	Employees (Persons)	Revenue (THB)	Employees (Persons)	Revenue (THB)
Micro	≤ 5	≤ 1.8 million	≤ 5	≤ 1.8 million
Small	≤ 50	≤ 100 million	≤ 30	≤ 50 million
Medium	≤ 200	≤ 500 million	≤ 100	≤ 300 million

Source: SME definition by Office of Small and Medium Enterprise Promotion (OSMEP) (https://sme.go.th).

By the new definition in 2019, there were 3,105,096 SMEs in Thailand comprising 99.53% of total enterprises [3]. In the same year, SMEs accounted for 68.50% of the workforce. Thai SMEs also contributed to 12.5% of total exports and 16.20% of total imports by value in 2019. Micro enterprise is the new category in the new definition and there were 2,645,084 micro enterprises, or 85.19% of total SMEs. The SMEs in the new time period and definition have contributed less GDP than those in the old definition. This is due to the new definition shifting focus to revenues that reflect directly to the GDP instead of their fixed assets. However, SMEs are a majority of Thai enterprises, reflecting the huge income gap between large enterprises and SMEs.

FIGURE 6.2

NUMBER OF SMES IN THAILAND AND THEIR SECTORS IN 2019



Source: Dashboard SME Big Data (https://sme.go.th).

Thailand is an economy that depends largely on exports of goods and services. Over the past 20 years, industrial products accounted for more than 70% of total export revenues. Since then, the manufacturing sector, which has been supported by domestic supporting industries, has vitalized the country. The key element of the supporting industries is SMEs. Thai SMEs have been through changes following the national development plans and development of the world economy. Since 1993, Thailand has seen increased investment from overseas. After the petrochemical industry had been developed in the Eastern Seaboard areas, more industrial estates were established to utilize the output from these upstream industries. Different kinds of industries started to invest in Thailand, especially the automotive, electronics, and electrical appliances. As a result, a large number of supporting industries grew, and SMEs marked an important part of the nation where labor in the agriculture sector could move to the manufacturing and services sectors.

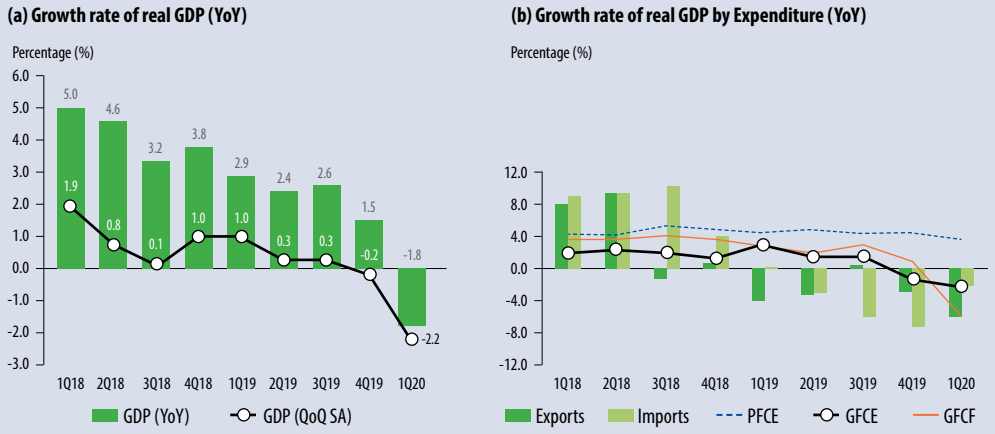
The 3.1 million SMEs in Thailand support four sectors - traders, services, manufacturers, and agriculture (see Figure 6.2) [3], with 530,698 SMEs representing the manufacturing sector. The income data in 2018 shows Thai SMEs contributed 25.89% of total income from total enterprises while manufacturing contributed 21.24% of the SMEs' income.

SMEs are considered to be the best engine to drive economic growth because they are the business unit that creates the biggest profit margins for the country compared to the bigger scale enterprises, where a huge portion of revenue is used for imported machinery, technologies, and materials. Moreover, SMEs develop wealth and prosperity in the rural areas of Thailand.

The advantages of Thai SMEs are their operational flexibility, close proximity to the market, and having the adaptability to rapidly respond to market needs. However, there are also many obstacles, such as out-of-date technology and high operating costs. The small size of SMEs usually translates to small income where there are many lacks - skilled labor, product brand development, understanding of modern business management, and marketing knowledge and information. These are in addition to low efficiency and productivity, and difficulties in accessing supporting technologies and financial resources.

FIGURE 6.3

GROWTH RATE OF REAL GDP



Source: GDP Q1/2020, Office of the National Economic and Social Development Council (https://www.nesdc.go.th/).

GDP in the first quarter of 2020 dropped by 1.8%, compared to a rise of 1.5% in Q4 2019, as a result of decreases in total exports of goods and services, private and public investments, and government's final consumption expenditure [4]. However, private final consumption expenditure grew at a decelerated rate. Due to the outbreak of the COVID-19 pandemic, GDP growth is expected to fall to -6.7% in 2020 and pick up to 6.1% in 2021, subject to the post-pandemic global economic recovery.

On production, the agricultural sector decreased by 5.7%, mainly due to droughts. Nonagricultural sector was lower by 1.4%, in contrast to the 2.0% rise in Q4 2019. This was resultant from the decrease in two sectors - manufacturing by 2.7% and services by 1.1%, as opposed to a fall of 2.2% and a rise of 4.1% in the previous quarter, respectively [4]. The decline in the service sector was due to the reduced number of tourists arriving into the country which impacted tourism and tourism-related sectors, particularly transportation, storage, accommodation, and food service activities. Meanwhile, key service sectors namely, wholesale and retail trade, repair of motor vehicles and motorcycles, information and communication, and real estate activities showed decelerated growth.

Contraction of manufacturing production was seen across the sector, including light, raw material, and capital and technology industry. These were attributed to softened domestic and external demand in major manufacturing industries, such as motor vehicles, food products, and nonmetallic mineral products.

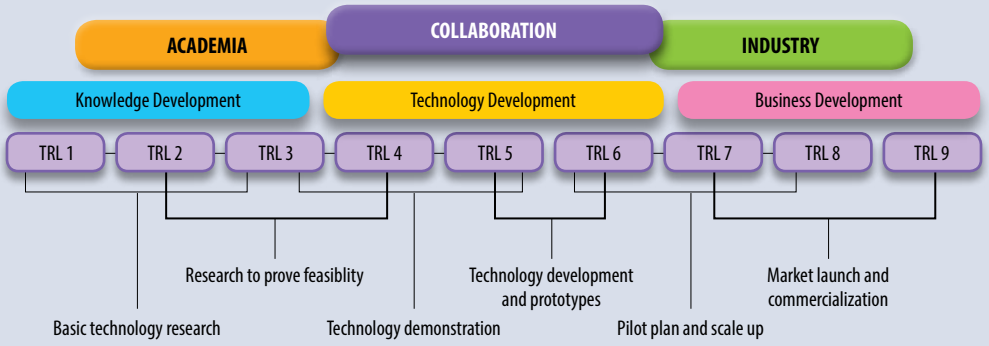
Technological Innovation, Business Model, and Market Development

Technological innovation is a part of the total innovation discipline. It focuses specifically on technology and the way it successfully integrates in products, services, and processes. Technology as a body of knowledge might thus be seen as a building block for technological innovation, serving as a cornerstone to research, design, development, manufacturing, and marketing.

Business models are fundamentally linked with technological innovation, yet the business model construct is essentially separable from technology. Technology development can facilitate new business models, but business model innovation can also occur without technology development.

FIGURE 6.4

INNOVATION CHAIN: CONVERTING SCIENCE INTO WEALTH [5]



Source: uk-cpi.com.

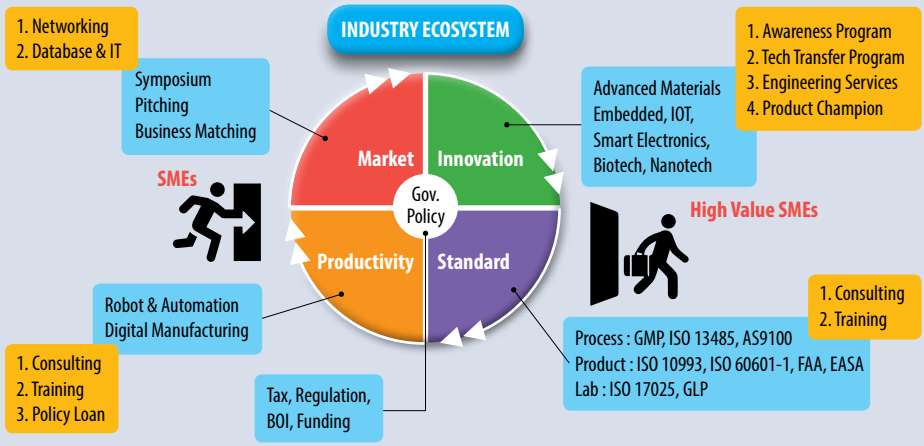
To measure the degree of technological development, the Technology Readiness Level (TRL) is used to describe the maturity of new technologies under development. It helps monitor and adapt their progress route toward larger system integration and/or market launch. This enables a better execution

in terms of project performance, schedule and budget. The scale is appreciated for its ability to improve risk management, resource allocation, and project coordination. TRLs show how close the innovation to the market is from the knowledge development to business development, so transitions in each TRL level show the connection among technological innovation, business model, and market development. TRL is the key indicator to promote the research to the market for the Ministry of Higher Education, Science, Research and Innovation, National Science and Technology Development Agency (NSTDA), and universities.

The Department of Industrial Promotion (DIP) under the Ministry of Thailand has applied Innovation to Market Cycle to drive the innovation of Thai SMEs to the market. There are four stages in the cycle - innovation, standard, productivity, and market. Market will drive Innovation by providing the needs of customers to the researchers. The researchers will create innovation to meet the quality in accordance to the industry standard. The production processes are designed to produce products with standard quality and at minimum cost. Cost of production and production quality standard are also significant factors for market competition. Government policies play as a supporting mechanism to drive the innovative industry ecosystem. Technological innovation is developed at the innovation stage while the business model at the standard and productivity stage. Market development is promoted in the market stage via DIP's training and consulting programs.

FIGURE 6.5

INNOVATION TO MARKET CYCLE FOR INDUSTRY PROMOTION



Source: uk-cpi.com.

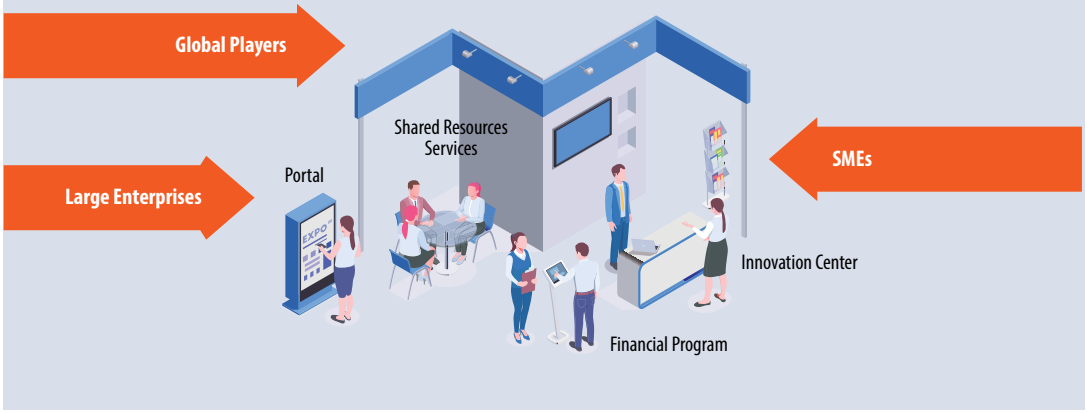
Government-Academia-Industry Collaborations for Industry 4.0 in Manufacturing Sectors

The triple helix model of Innovation is a set of interactions between academia, industry, and government to foster economic and social development. Many universities, industries, and government collaborations have resulted in the establishment of research institutes, science parks, technology-transfer offices, and other hybrid organizations. To date, many large and international enterprises have received the benefits of such organizations and set their research laboratories in science parks. However, many works from the research institutes are too advanced to be applied to Thai industries, especially the SMEs. Researchers mainly focus on publishing their works internationally thus their research focus is a mismatch to the SMEs, in terms of SMEs being a supporting industry and the technology application in their manufacturing processes.

In 2017, collaboration between the DIP and NSTDA saw the launch of a new platform to motivate Thai SMEs to create innovation. The platform called "Innovation to Industry Platform" or "i2 (i-square)" uses the budget allocated by the Ministry of Digital Economy and Society of Thailand, NSTDA research teams, and the DIP industrial network. There are four functions in the platform.

FIGURE 6.6

'INNOVATION TO INDUSTRY PLATFORM' AT THE ITC



i) Portal

The portal is the place for business matching. Project coordinators employed by the Industry Transformation Center (ITC) work on matching the demand of technology from the SMEs to the supporting technology from innovators or startups. The project coordinators will also be the bridge in bringing government project to support SMEs by cooperating with DIP.

ii) Innovation center

This is where the research takes place. When interesting projects from SMEs show to have a high impact on the industry, it is selected to carry out research works with research institutes or large enterprises. The researchers will be recruited from NSTDA or universities, depending on the specifications of the projects and grants from the National Research Council of Thailand.

iii) Shared resource services

Shared resource services is the place to share and try out new technologies. Large enterprises or startups can show their product or machine innovation while SMEs are able to try them with the support from the government. If the SMEs are satisfied with the demonstrated product or machinery, they can purchase the technology from the technology owners. In 2018, the ITC showcased several food processing technologies, such as freeze dryers, spray dryers, high-speed extractors, retorts, 3D printers, label printers, etc., that allowed Thai SMEs to try them for free.

iv) Financial program

Venture capital loans and research funding are found here. The SME project can be incubated and pitched for funding. By cooperating with InnoSpace (Thailand), the deep-tech startups have an opportunity to raise funds from InnoSpace (Thailand) partners consisting of Thailand's large enterprises.

Initiated in January 2019, InnoSpace (Thailand) is a joint venture between the public and private sectors that raised a capital of THB640 million in its first stage of funding, higher than the targetted THB500 million, with the participation of 13 agencies taking part as startup incubators [6]. Key partners included PTT, Siam Cement Group, CP Group, ThaiBev, the Electricity Generating Authority of Thailand, Bangkok Dusit Medical Services, Siam Commercial Bank, Thai Union, Sahapat Group, Bangkok Bank, Krungthai Bank, Kasikorn Bank, and SME Development Bank. Similar to the Thai stock market exchange, InnoSpace (Thailand) will be the optional funding place for young startups to get venture capitals from large enterprises.

FIGURE 6.7

PARTNERSHIPS OF LARGE THAI COMPANIES IN ESTABLISHING INNOSPACE (THAILAND)

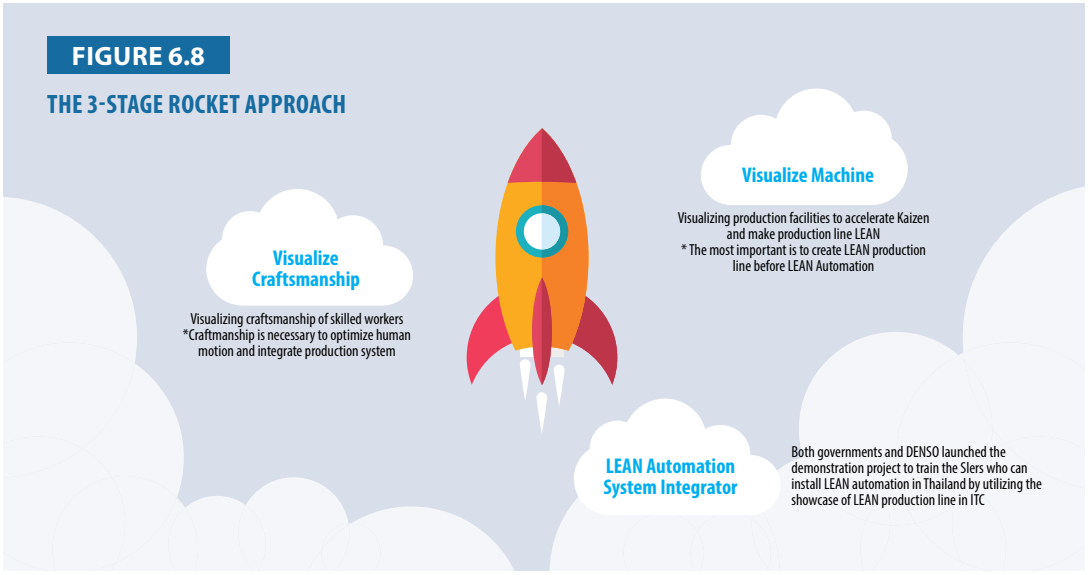
Source: Innospace (Thailand) (http://www.innospacethailand.com.

Government-Academia-Industry Collaborations on Manufacturing Transformation: 3-Stage Rocket Approach Project

Industry 4.0 or Smart Factory began in Thailand since Germany promoted Industry 4.0 in 2013. The Federation of Thai Industries (FTI) supported the idea that Industry 4.0 will be the key success factor to lift Thai industries and economy from the middle-income trap. The Thai government also promoted and backed the FTI to implement Industry 4.0. While there are many manufacturing transformation taking place, most are carried out by large international enterprises because it requires high investment that only large or medium-large enterprises can afford.

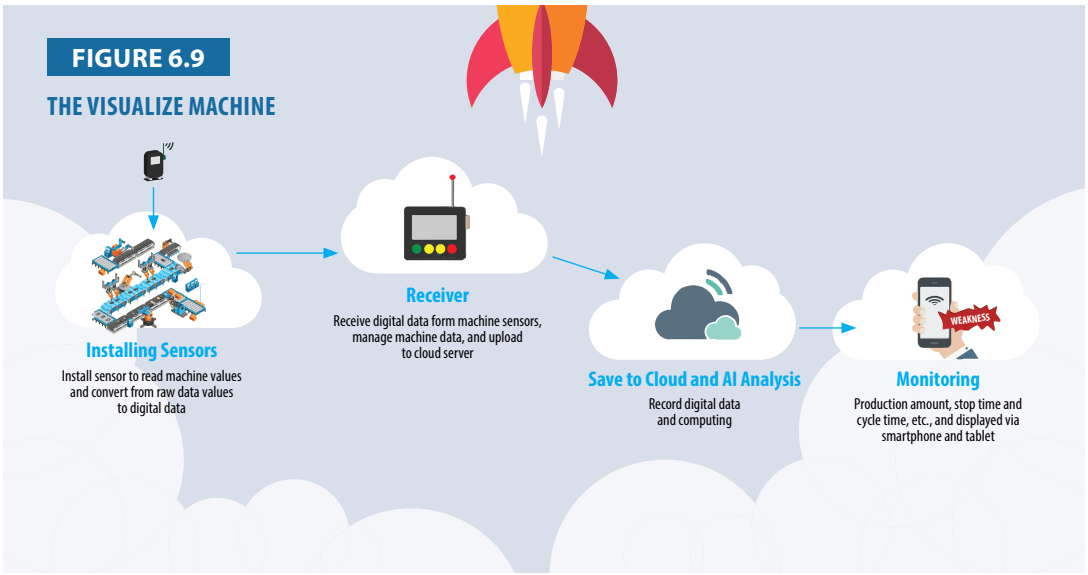
In 2018, Thailand's Ministry of Industry (MOI) collaborated with the Ministry of Economy, Trade, and Industry (METI) of Japan under the Connected Industry Scheme. The project called "3-Stage Rocket Approach" was initiated from the cooperation among Japanese private companies, Thai universities, Thai research institutes, and DIP. The objective of this project is to strategically transfer Industry 4.0 or "Connected Industry" to Thai SMEs, especially in the manufacturing sector.

As Thai SMEs have lower capital to invest in Industry 4.0, they will only do so when it appears to be worth it. Thus the 3-Stage Rocket Approach project proposed the procedure of implementation instead of focusing on interesting technology. The three stages to implement Industry 4.0 are Visualize Machine, Visualize Craftsmanship, and Lean Automation System Integrator [7].



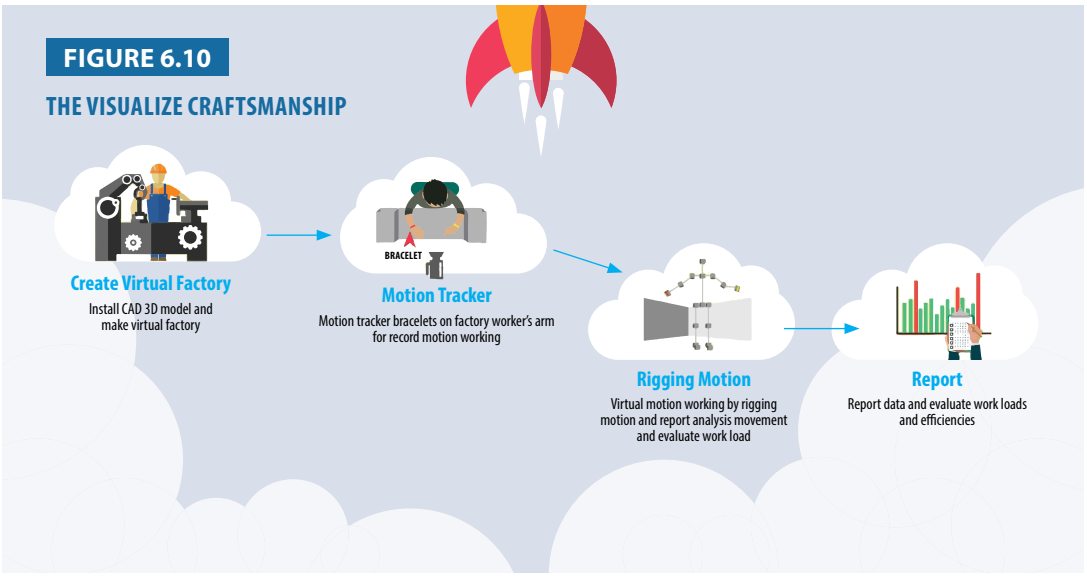
Stage 1: Visualize Machine

To monitor the utilization of machinery and equipment in the manufacturing processes, the remote sensing technology is applied to monitor the machine process capabilities. The price of sensors is cheaper now, making it practical to install sensors to target machines and monitor through the mobile application as the start of Industry 4.0 application. There isn't a need to fully monitor all processes in the factory and only key manufacturing processes are monitored. When SMEs start to monitor their processes, they know how to manage their fixed assets efficiently.



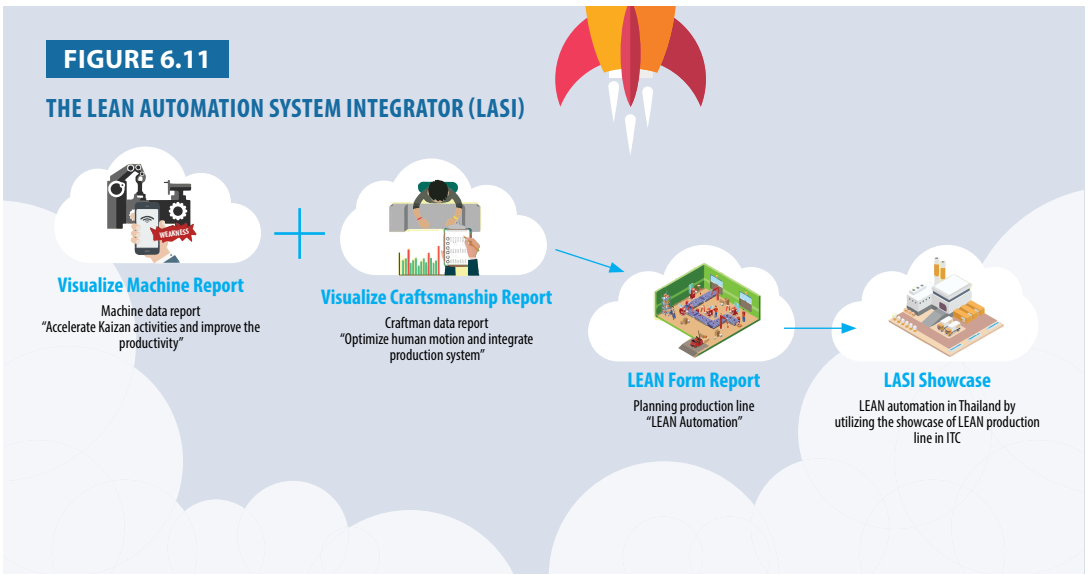
Stage 2: Visualize Craftsmanship

To monitor the utilization of workforce in the manufacturing processes, the motion capture and visual inspection technologies are applied to monitor the working process capabilities. With these technologies, the motion and time study can enhance productivity improvement to a new level. The movement of workforce can be captured and analyzed in real time and AI can check work sequences properly and sometimes reduce the workload of the final inspector.



Stage 3: Lean Automation System Integrator (LASI)

To apply robot and automation without lean management is a waste of money. Overproduction, inventory, waiting, motions, defects, transportation, and overprocessing are seven wastes that regularly happen in the manufacturing process. Although robots and automation can perform repeated jobs faster and more efficiently than human, it is particularly important that the robots and automation are applied to the right tasks. Lean management is applied to the process right from the beginning to ensure minimum waste tasks in the manufacturing system. While the automation project focuses on bottleneck locations, the lean automation is adopted from semi-automation to full-automation line. The first step is to apply simulations to analyze cost of investment, value gain, and payback period on the automation project to identify the level of automation worth applying to the current process. The next step is to design lean to the automation system to ensure that all movement of mechanism in the automation are minimum as to consume less power and less processing time.



Japanese companies and DIP trained the System Integrators who will then apply the 3-Stage Rocket Approach to Thai SMEs. System Integrators were selected from the teaching faculties in universities and vocational schools as well as engineers in the SMEs. DIP supports Thai SMEs by sending the System Integrators to diagnose the manufacturing process and implement the 3-Stage Rocket Approach project. Between 2018–19, more than 1,000 SMEs participated in the DIP program.

FIGURE 6.12

PRESENTATION DAY AFTER THE IMPLEMENTATION OF 3-STAGE ROCKET APPROACH

Beneficial Government Policies and Business Environment for Industry 4.0

International trade has had a growing role in the economy of Thailand. According to the World Bank, Thailand's export sector amounted to just 20% of GDP in 1977. However, in 2016, the value of Thailand's exports of goods and services jumped to 68.9% of GDP, compared with 19.6% for China and 19.1% in India. In 2017, Thailand realized that the country had fallen in the middle-income trap when its wage rates became too high for it to compete against low-wage, low-income nations. Thailand also lacked sufficient innovation and highly skilled personnel to compete effectively against the highest tiers of knowledge-intensive products from Japan, Germany, and the USA.

To overcome this situation, the government launched Thailand 4.0 with aims to transform the country from a middle-income nation into one that can compete against wealthier, more knowledge-based economies. Thailand 4.0 is an economic model based on creativity, innovation, new technology, and high-quality services. The development plan is focused on 10 targeted industries, which can be divided into two segments:

(i) Further developing existing industrial sectors by adding value through advanced technologies for five industries

- Next-generation automotive
- Smart electronics
- High-income tourism and medical tourism
- Efficient agriculture and biotechnology
- Food innovation

ii) Five additional growth engines to accelerate Thailand's future growth

- Automation and robotics
- Aerospace
- Bio-energy and biochemicals
- Digital
- Medical and healthcare

TABLE 6.2

TRANSFORMATION IN THAILAND 4.0

Traditional farming	Smart farming
Traditional SMEs	Smart enterprises/Startups
Buy technologies	Make technologies
Traditional services	High-value services
Unskilled labors	Knowledge workers/High-skilled labors

Board of Investment and Eastern Economic Corridors (EEC)

Chachoengsao, Chonburi, and Rayong provinces have been designated for the development of the Eastern Economic Corridor (EEC), a pilot project for the economic development of Thailand's Eastern Seaboard. Over the past 30 years, these three provinces have been developed to support the fast-growing industries. It was the "eras of industrial revolution". In 1987, Map Ta Phut industrial estate was established and it was the beginning of the development of Thai heavy industry, such as petrochemical, auto, and electronics industries. These eras are also called Thailand 3.0. Today, Thailand is ready to move forward to the era of Thailand 4.0.

On 1 February 2018, the Thai parliament approved the law for trade and investment in the EEC. With the EEC, Thailand hopes to develop its eastern provinces into a leading ASEAN economic zone. The EEC straddles the three eastern provinces off the coast of the Gulf of Thailand and spans a total of 13,285 sq km. The government hopes to complete the EEC by 2021, turning these provinces into a hub for technological manufacturing and services with strong connectivity to its ASEAN neighbors by land, sea, and air. As of 1 January 2018, the EEC has attracted USD9.3 billion in foreign direct investment (FDI), according to data provided by Thailand's Board of Investment.

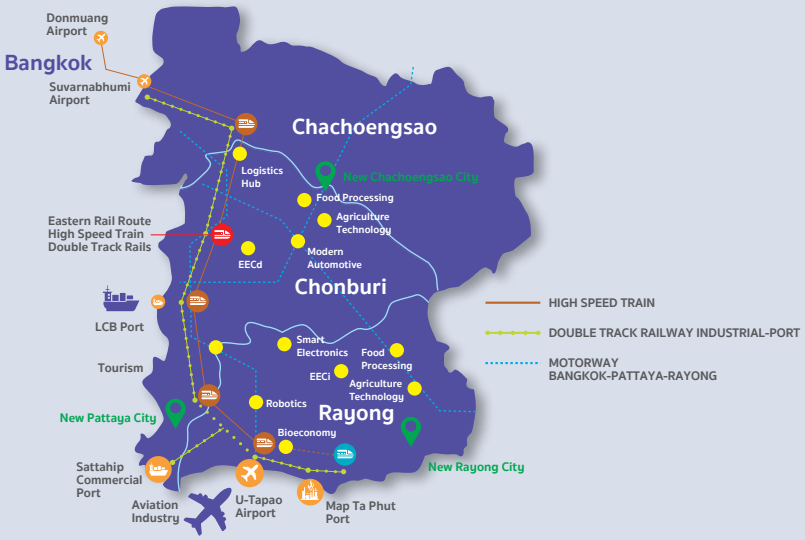
A major focus of the EEC is to improve existing connectivity and foster manufacturing and innovation. The government envisions creating established sea routes from the eastern provinces of Thailand to Myanmar's on-going Dawei deep-sea port project, Cambodia's Sihanoukville port, and Vietnam's Vung Tau port. The government is expanding the Laem Chabang seaport - the largest in the country - with the goal of transforming it into a marine hub of Southeast Asia.

To improve connectivity by air, Thailand is expanding the U-Tapao airport in Rayong province. With the opening of a second passenger terminal and runway, the U-Tapao airport's passenger capacity will increase from 800,000 people to 3 million people. The expansion will not only facilitate an increase in tourist arrivals who are drawn to Thailand's eastern beaches, but also transform U-Tapao into a hub for aviation maintenance, repair and overhaul, air cargo, and logistics.

Road connectivity will improve with the development of high-speed and double-track railways linking ports, airports, industrial clusters, and major urban centers throughout Thailand.

FIGURE 6.13

CONNECTIVITY IN THE EEC [8]



Source: Eastern Economic Corridor (EEC) (https://www.eeco.or.th).

In the EEC area, Thailand's Board of Investment offers incentives as the followings:

i) Corporate income tax exemption of up to 15 years

ii) Exemption of import duty on machinery, raw and essential materials used for export products, and products used for R&D

iii) Financial incentives for investment in R&D and innovation in human resources development in targeted industries

iv) Permit to own land used for Board of Investment promoted projects

v) Facilitation for visas and work permits

The manufacturing transformation must have the collaboration from the government, academic, and industry to be successful. As such, it is mandatory for the key stakeholders in Thailand to participate in the manufacturing transformation and integrate their policies. They are as the following:

i) OSMEP

ii) DIP under MOI

iii) NSTDA under Ministry of Higher Education, Science, Research and Innovation and universities

iv) Digital Economy Promotion Agency (DEPA) under Ministry of Digital Economy and Society (MDES)

v) Federation of Thai Industries (FTI)

SUCCESSFUL BUSINESS STRATEGIES FOR MANUFACTURING TRANSFORMATION

Sectoral Coverage

The Factory Act of 1992 (which replaces the Factory Act of 1969, 1975, and 1979) determines regulations for factory establishment and operation, factory expansion, and safety requirements.

TABLE 6.3

INDUSTRY CATEGORIES CONTROLLED UNDER THE FACTORY ACT

1. Basic agro-industry	8. Furniture & fixture	15. Nonmetal products
2. Food	9. Paper & paper products	16. Basic metal products
3. Beverage	10. Printing, publishing, allied products	17. Fabricated products
4. Textile	11. Chemical & chemical products	18. Machinery
5. Wearing apparel	12. Petroleum products	19. Electrical machinery and supplies
6. Leather products & footwear	13. Rubber products	20. Transport equipment
7. Wood & wood products	14. Plastic products	21. Other manufacturing industries

Table 6.4 shows that Thai industries cover all traditional sectors, but most Thai industries are in basic agro-industry while the transport equipment and food industries have the highest number of workforce in Thailand. The Office of Industrial Economics (OIE) in the Ministry of Industry plays an important role in preparing, integrating, and driving the industrial development policies toward sustainable growth. OIE's tasks encompass surveying, collecting, and analyzing the Thai industrial indices and the utilization of these indices are reported every month, which is key information. In May 2020, the Output index showed that the Thai industrial economy has declined for a consecutive three months because of the COVID-19 outbreak.

In Table 6.5, from the study of impact from COVID-19 crisis to Thai industries, there are some positive industry earners, such as the chemical fertilizer industry, canned foods, and medicine and drugs because people work at home, do some farm works, and store essential products for living. However, significant industries, like the automotive and petroleum declined drastically that the FTI urgently requested the MOI to come up with stimulating policies for automotive industry in Thailand.

Although the COVID-19 crisis is still persistent globally with unknown period of recovery, Thai industries must transform to the 'new normal' by adopting Industry 4.0 technologies and get the industries to rethink about managing cash flow, labor costs, and investment costs. Many Thai industries can use this opportunity to reengineer their manufacturing line and increase the level of standards as to come back to compete in the global market post-COVID and once global trading activities begin actively again. DIP plays an important task in helping the recovery of the Thai industry and to get the SMEs to work under the new norms.

TABLE 6.4

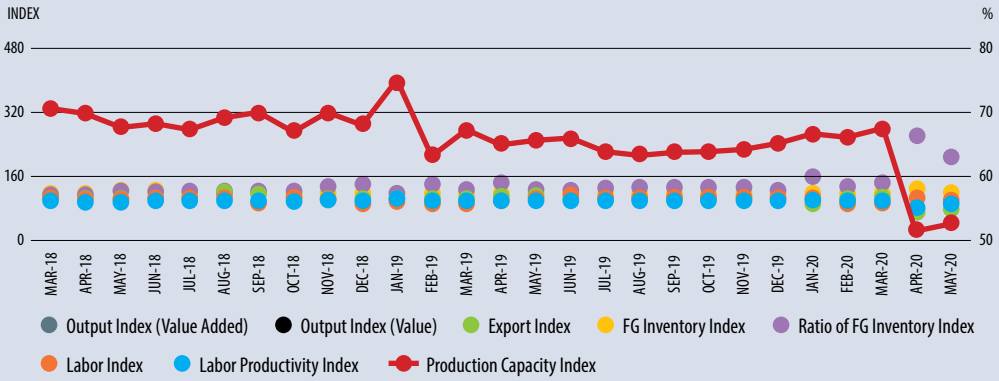
CAPABILITIES OF THAILAND'S INDUSTRY SECTOR [9]

No.	Industrial Sector	Enterprises (number)	Capital (THB million)	Workforce (persons)
1	Basic Agro-Industry	42,750	268,285	164,944
2	Food	9,516	729,319	517,395
3	Beverage	873	129,824	31,985
4	Textile	2,570	166,729	215,270
5	Wearing apparel	2,161	38,817	244,716
6	Leather products & footwear	999	32,185	82,283
7	Wood & wood products	5,760	129,311	145,972
8	Furniture & fixture	3,571	33,032	99,315
9	Paper & paper products	1,371	148,266	59,803
10	Printing, publishing, allied products	2,601	81,549	64,775
11	Chemical & chemical products	3,556	655,682	123,322
12	Petroleum products	894	215,532	14,607
13	Rubber products	2,283	251,279	147,173
14	Plastic products	6,705	336,639	266,324
15	Nonmetal products	7,616	341,691	161,268
16	Basic metal products	1,100	269,701	57,480
17	Fabricated products	12,755	424,887	312,557
18	Machinery	5,147	415,402	198,536
19	Electrical machinery and supplies	2,919	594,324	383,467
20	Transport equipment	9,589	796,382	328,043
21	Other manufacturing industries	14,071	1,781,764	398,241
	Total	**138,807**	**7,840,601**	**4,017,476**

Source: Department of Industrial Works (DIW), MOI in 2019 (http://www.diw.go.th).

FIGURE 6.14

THAILAND'S INDUSTRIAL INDEX IN MAY 2020 [10]



Source: OIE, MOI in May 2020.

TABLE 6.5

TOP FIVE AFFECTED INDUSTRIES UNDER INDUSTRY INDICES IN MAY 2020 [11]

No.	Industry			No.	Industry		
1.	**Chemical Fertilizer and Nitrogen Compound**			1.	**Automotive**		
	- Output Index	+24.89%	🟢		- Output Index	-68.73%	🔴
	- Delivery Index	-22.35%	🔴		- Delivery Index	-65.15%	🔴
	- FG Inventory Index	+38.03%	🟢		- FG Inventory Index	-5.19%	🔴
2.	**Canned Food**			2.	**Petroleum**		
	- Output Index	+21.15%	🟢		- Output Index	-16.81%	🔴
	- Delivery Index	+39.42%	🟢		- Delivery Index	-8.27%	🔴
	- FG Inventory Index	-0.10%	🔴		- FG Inventory Index	-19.21%	🔴
3.	**Drugs and Medicine**			3.	**Air Conditioners**		
	- Output Index	+10.07%	🟢		- Output Index	-46.84%	🔴
	- Delivery Index	-9.94%	🔴		- Delivery Index	-43.58%	🔴
	- FG Inventory Index	+62.59%	🟢		- FG Inventory Index	+4.11%	🟢
4.	**Milk Product**			4.	**Tires**		
	- Output Index	+5.99%	🟢		- Output Index	-58.25%	🔴
	- Delivery Index	+5.38%	🟢		- Delivery Index	-46.35%	🔴
	- FG Inventory Index	-0.33%	🔴		- FG Inventory Index	-4.61%	🔴
5.	**Frozen Food**			5.	**Iron and Steel**		
	- Output Index	+5.08%	🟢		- Output Index	-25.41%	🔴
	- Delivery Index	-0.40%	🔴		- Delivery Index	-20.28%	🔴
	- FG Inventory Index	+20.76%	🟢		- FG Inventory Index	-6.11%	🔴

🟢 **Positive Effect** 🔴 **Negative Effect**

Source: Office of Industrial Economics (OIE), Ministry of Industry.

Selected Case Studies on Manufacturing Firms

In 2018–19, more than 1,000 SMEs joined the 3-Stage Rocket Approach. To recap, the three stages to implement Industry 4.0 are Visualize Machine, Visualize Craftsmanship, and Lean Automation System Integrator. The SMEs that joined the program can choose to implement the stages they want. Considering the top highest outcome of the application from each company, three manufacturing firms were selected as successful case studies and their CEOs were interviewed in accordance to the research framework and guidelines provided to National Experts.

Case Study 1: King's Stella Laboratory Co., Ltd.

Company	King's Stella Laboratory Co., Ltd.
Address	98 Moo 1 Niyom-KaoKaew Road, Khlong Niyom Yattra, Bang Bo, Samut Prakan 10560
Product	Air conditioning, car care, and household products
Size (Employees)	200
Capital	THB50 million (USD 1.6 million)
Year of establishment	2003
Market	Domestic 80%:International 20%
Standard	ISO 9001:2015; HACCP; Halal; Thai-FDA
Product	
Application	King's Stella applied Visualize Machine and Visualize Craftsmanship technology to the production line and bottlenecks were identified in three areas. Modification: Two automation machines - automatic gel quantity inspection and automatic gel refill system - were installed to replace the existing system.
Outcome	Efficiency up 23%; Cost down 33%; Estimated benefit THB17.2 million/year

FIGURE 6.15

KING'S STELLA LABORATORY CO., LTD.

Case Study 2: L&E Manufacturing Co., Ltd.

Company	L&E Manufacturing Co., Ltd.
Address	85/3 Soi Pratumporn Changwattana Road, Thung Song Hong, Laksi, Bangkok
Product	Lighting and equipment
Size (Employees)	220
Capital	THB25 million (USD0.83 million)
Year of establishment	1993
Market	Domestic 100%
Standard	ISO 9001:2015 ISO 45001 ISO 14001 TLS8001 IEC 17025
Product	
Application	L&E applied Visualize Machine technology to monitor the production process. The arc machine was detected as bottleneck. Modification: Added two automotive feeders to increase productivity.
Outcome	Efficiency up 22.3%. Estimated benefit THB4.8 million/year.

FIGURE 6.16

L&E MANUFACTURING CO., LTD.

Case Study 3: Chong Thai Rung Ruang Co., Ltd.

Company	Chong Thai Rung Ruang Co., Ltd.
Address	138/71 Moo.8 Soi Tharnchareon, Rangrod Faikao Road, Bangduan, Muang, Samutprakarn 10270
Product	Machining parts, jigs and fixtures, molds and dies
Size (Employees)	83
Capital	THB5 million (USD170,000)
Year of establishment	2011
Market	Domestic 100%
Standard	ISO 9001:2015
Product	CHONG THAI RUNG RUANG CO., LTD.  
Application	Chong Thai Rung Ruang applied the Visualize Machine technology to production process. The tool setup process took too much time and was identified as a bottleneck. Modification: An automatic presetter was installed to improve productivity.
Outcome	Efficiency up 3%; Reduce workforces 63%; Estimated benefit THB5.3 million/year

FIGURE 6.17

CHONG THAI RUNG RUANG CO., LTD.

DATA AVAILABILITY

Primary Data - Focus Group Interviews

Case Study 1: King's Stella Laboratory Co., Ltd.

Interview: Virasinee Kittikasemsak (Managing Director)
Date: 19 June 2020

A. Economic Alignment

1. **What are the economic and industry environments and how does the company strengthen the alignment with the market demand (including customer communication channels)?**

   - There are a lot of competitors from local to global companies that propose a variety of products for spray deodorization. The online platform is a tool to communicate the product specification and value proposition to consumers. The manufacturers that are not only a brand but also OEMs need to have high capability in technology, R&D, and continuous improvement so they can offer high quality products at reasonable prices.

   - King's Stella Laboratory is a pioneer that has manufactured and distributed the air conditioning spray in Thailand under the brand "King's Stella" since 1963.

2. **Does the company have a clear idea of which market trends are likely to have the greatest impact on the company over the next three years?**

   - Yes. A market trend of this product will relate to a competition of innovation, variety of products, speed of service, and online marketing.

   - King's Stella invested in the laboratory and R&D team to develop new products as well as in new machines and automation technology that can improve manufacturing productivity and quality, and reduce cost.

3. **Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?**

   - Yes. King's Stella has continuous improvement and uses the automation system to reduce work force and labor costs.

4. **Are they maximizing their use of remote diagnostics, and other forms of direct feedback to improve the customer experience with their products and services?**

   - King's Stella has set up its IT team to sell products online and uses the QR Code in the products catalog. From the QR Code, there is an online channel for consumers to send feedbacks and suggestions as well as express satisfaction too. King's Stella uses these feedbacks to develop new products.

B. Technology Utilization

1. **What is the core technology innovation or adoption for manufacturing transformation and how does it connect to their business functions (business model)? E.g.: Technologies driven**

by big data, AI, the IoT, mobile and social computing, the cloud, and other innovative technologies (if any).

- King's Stella's core technology is in inspecting the raw material to ensure that the highest quality input is used in the factory. If the quality of raw material is high, there are fewer errors in the manufacturing, more efficiency, and saves cost for repair and reworks of defects.

2. **Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?**

- King's Stella applies enterprise resource planning (ERP) technology to manage the company and uses online meeting tools to communicate with local and global customers.

C. Talent Development

1. **Are there any skills gap for manufacturing at different levels of employees or managers?**

- Yes. There are skills gap for manufacturing in all levels - from employees to managers.

2. **How does the company respond to the needs of human resources and talent development?**

- When King's Stella recruit new employees, IT skills from basic to advance is an important requirement. King's Stella has training programs for new employees. Also, it is an efficient way to develop talents.

3. **Does the company have an effective HR strategy for recruiting, training, and retaining the talent needed for ongoing service transformation?**

- King's Stella's HR Strategy is to apply to many government and private projects to let the talent team learn from the experts in the project. After the project ends, this talented team will continue development works as part of the Kaizen way in the company.

D. Supply Chain Collaboration and Partnership

1. **Are there any complexities or challenges caused by distributed sourcing, engineering, and production?**

- No.

2. **How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?**

- Diverse partners usually help King's Stella improve product quality, use of equipment, new machines, and updated standards.

3. **Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?**

- Yes. Strategy and planning are always part of the company's vision and mission.

4. **Does the company have in place robust methods for coordinating strategy and planning throughout the organization and partner ecosystem?**

   - Yes. King's Stella has the plan to work with partners, especially in ASEAN.

E. Market Competitiveness

1. **What is the identified competitive advantage in domestic and global markets?**

   - King's Stella is a well-known brand and used by Thai consumers since 1963. The products cover many categories, such as air care, household, car care, and pet care.

2. **What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?**

Strengths	Brand name Product variety IT application in all activities in the company
Weaknesses	The investment capability in R&D, laboratory, and machine Large variety of products mean many inventories Large workforce in the manufacturing processes
Opportunities	Cost of machine and automation are cheaper than before Board of investment program and government support bring opportunities to improve business
Threats	COVID-19 crisis blocks imports and exports. Wage increases but quality remains the same

3. **How does the company deal with the competitors for a sustainable business model?**

   - R&D of new products while maintaining quality of the existing products. Apply modern management and invest in new technology.

4. **Does the company embrace a design, build, and service anywhere philosophy, and how do they compare to competitors' capabilities and customer expectations?**

   - King's Stella products cover more categories of products than its competitors. Also, King's Stella is now in the online market. The IT team is assigned to link product document using QR codes and apply IT tools to collect data on the needs of customers and customer satisfaction.

F. Innovation Ecosystem

1. **Are there any external sources (from the government, academia, or industry) supporting the company's business ideas generation and innovations?**

   - Yes. DIP helped implement Manufacturing Automation while the National Science and Technology Development Agency (NSTDA) supported in R&D and the Ministry of Energy supported on solar cells to reduce power costs.

2. **What is the mechanism of the strategic alliance as an innovation ecosystem and how does the company collaborate with and benefit from the ecosystem?**

   - Many government agencies offer supporting programs which help in increasing business competitiveness. King's Stella usually attends these programs and uses the government facility, such as ITC.

G. Strategic Management

1. **Does the company have strategic (measurable) objectives for manufacturing transformation? It can be one focused objective or normally multiple objectives from diverse perspectives (e.g., Financial Perspective - outlining the financial objectives; Customer Perspective - outlining the objectives related to customers and the market; Internal Process Perspective - outlining the internal business process objectives; Learning and Growth Perspective - outlining the objectives related to employees, culture and information system, etc.)**

   - King's Stella considers applying 5G technologies to control and monitor its machinery.

2. **What is the past performance over time in terms of the objectives?**

   - Cost of production and delivery time.

3. **Why the performance over time in the past?**

   - Wages continuously increase while skilled workforces are difficult to be recruited. So, the company's performance depends on its investment capability, Thailand's economy, sales volume, and cost of technology.

4. **Where is the anticipated performance in the expected period of future (e.g., the next three years)?**

   - Reduce cost of production in the next three years with 5G technologies.

5. **How does the company try to achieve the objectives of performance in the future?**

   - Human resource development though a variety of training programs and projects.

6. **What are the driving forces or resources that drive the performance and how are they managed?**

   - Global competition, economics, society, wages, and labor skills.

7. **What are the disadvantageous factors hurting performance and how can they be managed?**

   - Global competition, socioeconomic issues, such as the COVID-19. The company reduced manpower and created more space between workers by investing in digital technology.

H. Regulation of Operations

1. **Are there any rising standards from environmental concerns or standards-based factors, like ISO compliance that apply across an increasingly interconnected world?**

   - Yes, especially green and world-class quality standards.

2. **What are the impacts on the company and how are the issues resolved?**

   - COVID-19 crisis has led to the suspension of investment in the transformation project. Instead, the focus is diverted to risk management and carrying out production improvement.

Case Study 2: L&E Manufacturing Co., Ltd.

Interview: Gritsada Suptuaychone (Managing Director)

Akkhrapong Sasiaphiphuwong (Factory Manager)

Date: 24 June 2020

A. Economic Alignment

1. **What are the economic and industry environments and how does the company strengthen the alignment with the market demand (including customer communication channels)?**

   - Competition in R&D on new products that serve the needs of customers, domestically and internationally.

2. **Does the company have a clear idea of which market trends are likely to have the greatest impact on the company over the next three years?**

   - Market trends will be on product development on smart products with IoT.

   - Ability to improve productivity and machine precision will be the key success factors in this business competition.

3. **Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?**

   - Yes. L&E applied robotic and automation in the welding and assembly processes to reduce production cost.

4. **Are they maximizing their use of remote diagnostics, and other forms of direct feedback to improve the customer experience with their products and services?**

   - L&E uses the QR code technology to share product specifications to customers and to get feedback from customers through digital platforms.

B. Technology Utilization

1. **What is the core technology innovation or adoption for manufacturing transformation and how does it connect to their business functions (business model)? E.g.: Technologies driven by big data, AI, the IoT, mobile and social computing, the cloud, and other innovative technologies (if any).**

   - L&E's core technology is in lighting and equipment.

2. **Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?**

   - L&E core technology uses robot and automation in the manufacturing process.

C. Talent Development

1. **Are there any skills gap for manufacturing at different levels of employees or managers?**

   - Yes. There are skills gaps for manufacturing in all levels.

2. **How does the company respond to the needs of human resources and talent development?**

   - L&E specifies that new employees should have skills, especially in production technology and IT. The company supports human resource development with trainings, on-the-job training, and participating in government programs.

3. **Does the company have an effective HR strategy for recruiting, training, and retaining the talent needed for ongoing service transformation?**

   - L&E's HR strategy is to learn from experts of large companies or government programs by sending team members for trainings. They, in turn, apply the knowledge in the production line.

D. Supply Chain Collaboration and Partnership

1. **Are there any complexities or challenges caused by distributed sourcing, engineering, and production?**

   - No. L&E is ready to cooperate and outsource engineering or production.

2. **How does the company manage diverse partners across diverse dimensions of quality, compliance, and risk?**

   - Diverse partners bring with them expertise, skills, and know-how to L&E employees. However, it is not easy to deal with partners due to the differences in technology processes and company culture. To efficiently manage the partners, the industrial standards, such as ISO 9000, is used to ensure the partners produce high quality products.

3. **Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?**

   - Yes. L&E's business strategy ensures cooperation with partners to increase competitiveness as well as develop new products to respond to market trends.

4. **Does the company have in place robust methods for coordinating strategy and planning throughout the organization and partner ecosystem?**

   - Yes. L&E always ensures cooperation with partners to carry out product development and increase the market size.

E. Market Competitiveness

1. **What is the identified competitive advantage in domestic and global markets?**

   - The L&E brand is well-known to the Thai consumers and L&E's products and processes have received international standards, such as ISO 9001, ISO 14001, IEC 17025, SET AWARDS 2008, and SET AWARDS 2010.

2. **What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?**

Strengths	Brand name R&D and product testing Marketing in the modern trades International agency in Vietnam, Myanmar, and China Chinese partner who is the leader in LED, lamp, and IoT
Weaknesses	Labor cost is higher than in Cambodia, Laos, Myanmar, and Vietnam Low number of skilled labors. Labor force have poor English and communication skills
Opportunities	Chinese partner helps in marketing and productivity improvement Board of investment policies and government-supported programs create opportunities to invest in new technology
Threats	COVID-19 crisis blocks imports and exports Trade war between the USA and China

3. **How does the company deal with the competitors for a sustainable business model?**

   - The development of new process innovation gives the company an edge in lowering the cost of production and allowing to produce high quality L&E products with global standing. Additionally, L&E has the policy to respond quickly to customers' requests, resulting in more exports and higher income.

4. **Does the company embrace a design, build, and service anywhere philosophy, and how do they compare to competitors' capabilities and customer expectations?**

   - L&E designs and develops products and services with IoT technologies in order to meet customers' needs. The company also offers a bigger product range than the competitors.

F. Innovation Ecosystem

1. **Are there any external sources (from the government, academia, or industry) supporting the company's business ideas generation and innovations?**

   - Yes. There are external organizations supporting L&E, such as DIP and NSTDA.

2. **What is the mechanism of the strategic alliance as an innovation ecosystem and how does the company collaborate with and benefit from the ecosystem**?

   - L&E gets to learn about the supporting projects offered by FTI when participating and cooperating with government organizations, such as DIP.

G. Strategic Management

1. **Does the company have strategic (measurable) objectives for manufacturing transformation? It can be one focused objective or normally multiple objectives from diverse perspectives (e.g., Financial Perspective - outlining the financial objectives, Customer Perspective - outlining the objectives related to customers and the market, Internal Process Perspective - outlining the internal business process objectives, Learning and Growth Perspective - outlining the objectives related to employees, culture and information system, etc.)**

   - Yes. L&E's strategic objective is to increase revenue with various new product development by following the smart electronic trend, such as IoT technology while applying more smart technology to reduce production cost

2. **What is the past performance over time in terms of the objectives?**

   - Reduced cost of production and increased number of products that meet the global quality standard.

3. **Why the performance over time in the past?**

   - Change in technology.

4. **Where is the anticipated performance in the expected period of future (e.g., the next three years)?**

   - R&D of new products continuously.

5. **How does the company try to achieve the objectives of performance in the future?**

   - Learn and cooperate with partners on R&D in creating new products.

6. **What are the driving forces or resources that drive the performance and how are they managed?**

   - Global competition, economics, society, wages, and labor skills.

7. **What are the disadvantageous factors hurting performance and how can they be managed?**

   - The L&E team was not ready to embrace new technologies. So, L&E needs to prepare the team to be ready for them.

H. Regulation of Operations

1. **Are there any rising standards from environmental concerns or standards-based factors, like ISO compliance, that apply across an increasingly interconnected world?**

   - Yes. Green and environmental-related standards.

2. **What are the impacts on the company and how are the issues resolved?**

   - The COVID-19 crisis affected the company with reduced international trades. Also, investment plans for improvement projects are suspended. Now L&E is applying risk management and doing production improvement.

Case Study 3: Chong Thai Rung Ruang Co., Ltd.

Interview: Bunjong ChongThaiRungRuang (Managing Director)

Poranat ChongThaiRungRuang (Administrative Secretary)

Wuthipong Ruangkaew (Assistant Marketing Manager)

Date: 25 June 2020

A. Economic Alignment

1. **What are the economic and industry environments and how does the company strengthen the alignment with the market demand (including customer communication channels)?**

   - Competition in terms of product quality, price, and the capabilities of employees and machinery.

2. **Does the company have a clear idea of which market trends are likely to have the greatest impact on the company over the next three years?**

   - Yes. The market trend of this product will be the competition of innovation and how to apply IoT into products. CTR needs to invest in machinery and new technologies for high productivity and high precision.

3. **Does the company have an economic model that quantifies how the manufacturing transformation initiatives and priorities impact their revenue and costs?**

   - Yes. CTR used robots and automation in the manufacturing process.

4. **Are they maximizing their use of remote diagnostics, and other forms of direct feedback to improve the customer experience with their products and services?**

   - Not yet.

B. Technology Utilization

1. **What is the core technology innovation or adoption for manufacturing transformation and how does it connect to their business functions (business model)? E.g.: Technologies driven by big data, AI, the IoT, mobile and social computing, the cloud, and other innovative technologies (if any).**

   - CTR's core technology is manufacturing with vertical machine center (VMC), computer numerical control (CNC), and robots.

2. **Does the company's innovation efforts extend beyond traditional R&D to encompass all parts of the enterprise ecosystem?**

   - No.

C. Talent Development

1. **Are there any skills gap for manufacturing at different levels of employees or managers?**

   - Yes. There are skill gaps for manufacturing in all levels, from employees to managers.

2. **How does the company respond to the needs of human resources and talent development?**

   - CTR recruits new employees with production technology and IT skills, then train them with on-the-job training.

3. **Does the company have an effective HR strategy for recruiting, training, and retaining the talent needed for ongoing service transformation?**

   - CTR's HR strategy is to send team members to participate in R&D programs organized by the government or private companies, which are also viewed as a marketing channel. It is a strategic way to train team members on-the-job.

D. Supply Chain Collaboration and Partnership

1. **Are there any complexities or challenges caused by distributed sourcing, engineering, and production?**

   - No.

2. **How does the company manage diverse partners across diverse dimensions of quality, compliance, and risks?**

   - Diverse partners usually help CTR improve its technology in the production process.

3. **Does the company know how well strategy and planning are coordinated within and across their business functions to respond proactively to market trends?**

   - Yes. The cooperation with partners or customers is the business function of CTR and to respond proactively to market trends.

4. **Does the company have in place robust methods for coordinating strategy and planning throughout the organization and partner ecosystem?**

   - Yes. CTR cooperates with partners right from the beginning of R&D.

E. Market Competitiveness

1. **What is the identified competitive advantage in domestic and global market?**

   - CTR is well-known in the Thai industry sector for its ability to manufacture large metal parts, such as machine bases, molds and dies, and automotive jigs and fixtures. Also, CTR can design and carry out R&D on the manufacturing of large metal parts.

2. **What is the general understanding about the company's strengths, weaknesses, opportunities, and threats compared with major rivals?**

Strengths	Large machines R&D team is experienced in developing ship and unmanned aerial vehicle (UAV) parts
Weaknesses	Dependence on skilled labors Marketing from R&D projects with state-owned enterprises or very large companies, such as Electricity Generating Authority of Thailand (EGAT) produces large sale orders when R&D succeeds, but it is affected as R&D budget for new products is slashed when the economy is down
Opportunities	Government support for many R&D projects EEC project creates a lot of machining work Board of investment supports the investment of new technologies
Threats	Lack of skilled labors COVID-19 outbreak Trade war between the USA and PR China

3. **How does the company deal with the competitors for a sustainable business model?**

   - R&D carried out with customers.

4. **Does the company embrace a design, build, and service anywhere philosophy, and how do they compare to competitors' capabilities and customer expectations?**

   - Yes. CTR has experience in designing, building, and servicing equipment, tools, machines, and metal parts in various industries.

F. Innovation Ecosystem

1. **Are there any external sources (from the government, academia, or industry) supporting the company's business ideas generation and innovations?**

   - Yes, there are external organizations supporting R&D fund for innovation, such as NSTDA, National Research Council of Thailand (NRCT), and Program Management Unit (PMU).

2. **What is the mechanism of the strategic alliance as an innovation ecosystem and how does the company collaborate with and benefit from the ecosystem?**

   - CTR follows the industry network and participates in many government projects and programmes.

G. Strategic Management

1. **Does the company have strategic (measurable) objectives for manufacturing transformation? It can be one focused objective or normally multiple objectives from diverse perspectives (e.g.: Financial Perspective - outlining the financial objectives; Customer Perspective - outlining the objectives related to customers and the market; Internal Process Perspective - outlining the internal business process objectives; Learning and Growth Perspective - outlining the objectives related to employees, culture and information system, etc.)**

   - CTR uses new technology for design and development of new products while robots are used in the manufacturing process. CTR also uses ERP for the company management system.

2. **What is the past performance over time in terms of the objectives?**

   - The ability to design quality products to the market and lower cost of production.

3. **Why the performance over time in the past?**

   - Economic factors, marketing of the company, and change of new technology.

4. **Where is the anticipated performance in the expected period of future (e.g., the next three years)?**

   - Increase the number of R&D products with customers.

5. **How does the company try to achieve the objectives of performance in the future?**

   - Learn and work closely with high potential partners and customers.

6. **What are the driving forces or resources that drive the performance and how are they managed?**

   - Global competition, economics, society, wages, and labor skills.

7. **What are the disadvantageous factors hurting performance and how can they be managed?**

   - Lack of skilled labor which means CTR must upskill operators to be R&D-ready.

H. Regulation of Operations

1. **Are there any rising standards from environmental concerns or standards-based factors, like ISO compliance, that apply across an increasingly interconnected world?**

   - Yes. The aviation standard - AS 9100.

2. **What are the impacts on the company and how are the issues resolved?**

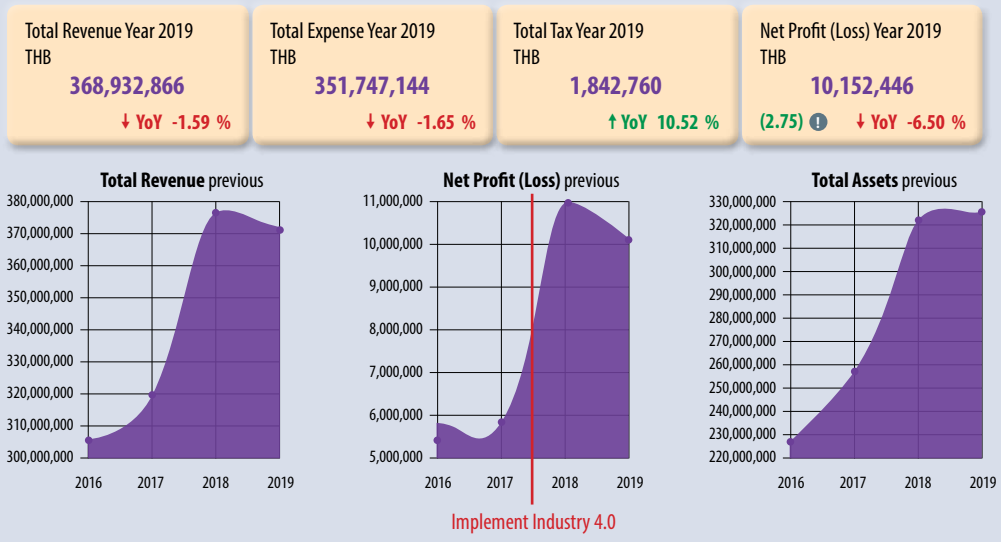
   - The COVID-19 crisis affected the company with reduced international trades. Also, investment plans for improvement projects are suspended. Now CTR is applying risk management and doing production improvement.

Secondary Data - Sources

Case Study 1: King's Stella Laboratory Co. Ltd.

FIGURE 6.18

COMPANY DATA ON KING'S STELLA LABORATORY CO., LTD [12]



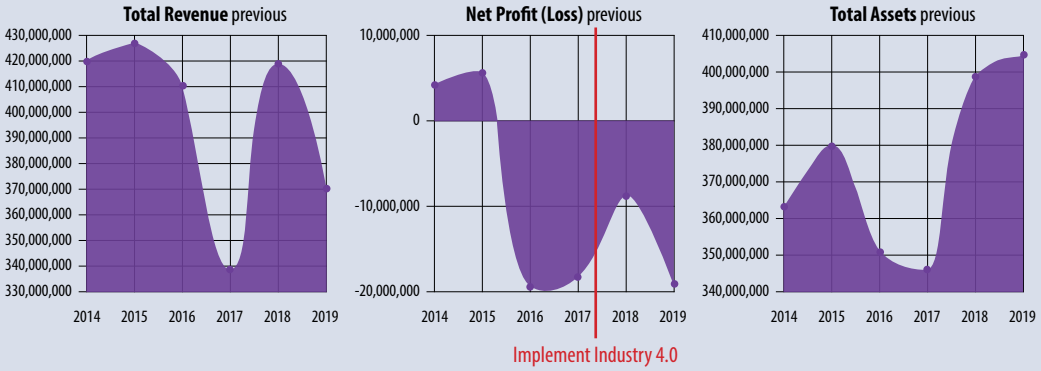
Source: Creden Credit Score (https://creden.co/).

Case Study 2: L&E Manufacturing Co., Ltd.

FIGURE 6.19

COMPANY DATA ON L&E MANUFACTURING CO., LTD [13]

Total Revenue Year 2019 THB	Total Expense Year 2019 THB	Total Tax Year 2019 THB	Net Profit (Loss) Year 2019 THB
371,363,863	384,405,031	0.00	-18,787,458
↓ YoY -10.96 %	↓ YoY -8.40 %		(-5.06) ↓ YoY 127.51 %



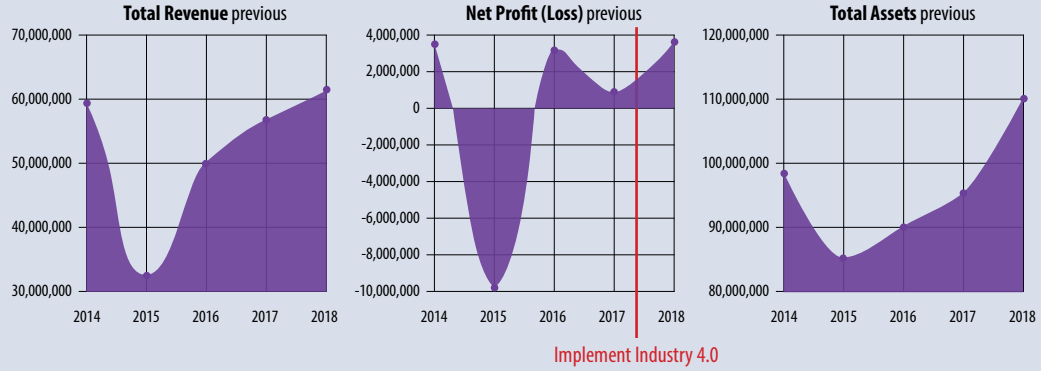
Source: Creden Credit Score (https://creden.co/).

Case Study 3: Chong Thai Rung Ruang Co., Ltd.

FIGURE 6.20

COMPANY DATA ON CHONG THAI RUNG RUANG CO., LTD [14]

Total Revenue Year 2018 THB	Total Expense Year 2018 THB	Total Tax Year 2018 THB	Net Profit (Loss) Year 2018 THB
61,486,656	56,328,004	1,420,216	3,370,426
↑ YoY 8.84 %	↑ YoY 5.72 %	↓ YoY -36.25 %	(5.48) ↑ YoY 410.81 %



Source: Creden Credit Score (https://creden.co/).

ANALYSIS OF CASE STUDIES

Analysis of Case Study 1: King's Stella Laboratory Co., Ltd.

Step 1: Evaluation based on BSC strategy map for diverse performance indicators

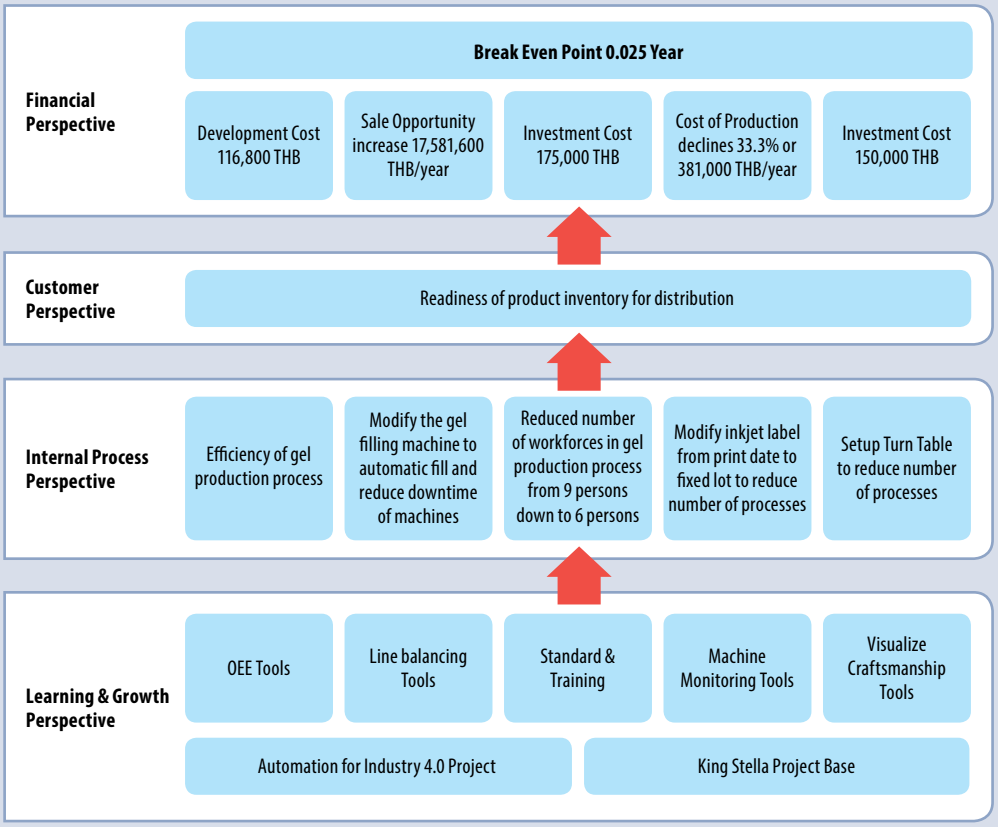
King's Stella used the strategy "King's Stella Project Base" by applying the 3-Stage Rocket Approach. The machinery and craftsmanship monitoring can identify the bottlenecks in the manufacturing process. Then, the productivity improvement process is applied by using automation technology and the company benefits from the technology investment.

From the Financial perspective, the improvement can increase productivity that in turn increases product sales to THB17.58 million while reducing 33% of its workers, from nine to six persons. It is estimated to save cost of about THB380,000.

From the Customer perspective, King's Stella has the ability to produce products in time and faster due to the increase of productivity, so it is possible for customers to save their inventory cost.

FIGURE 6.21

KING'S STELLA STRATEGY MAP



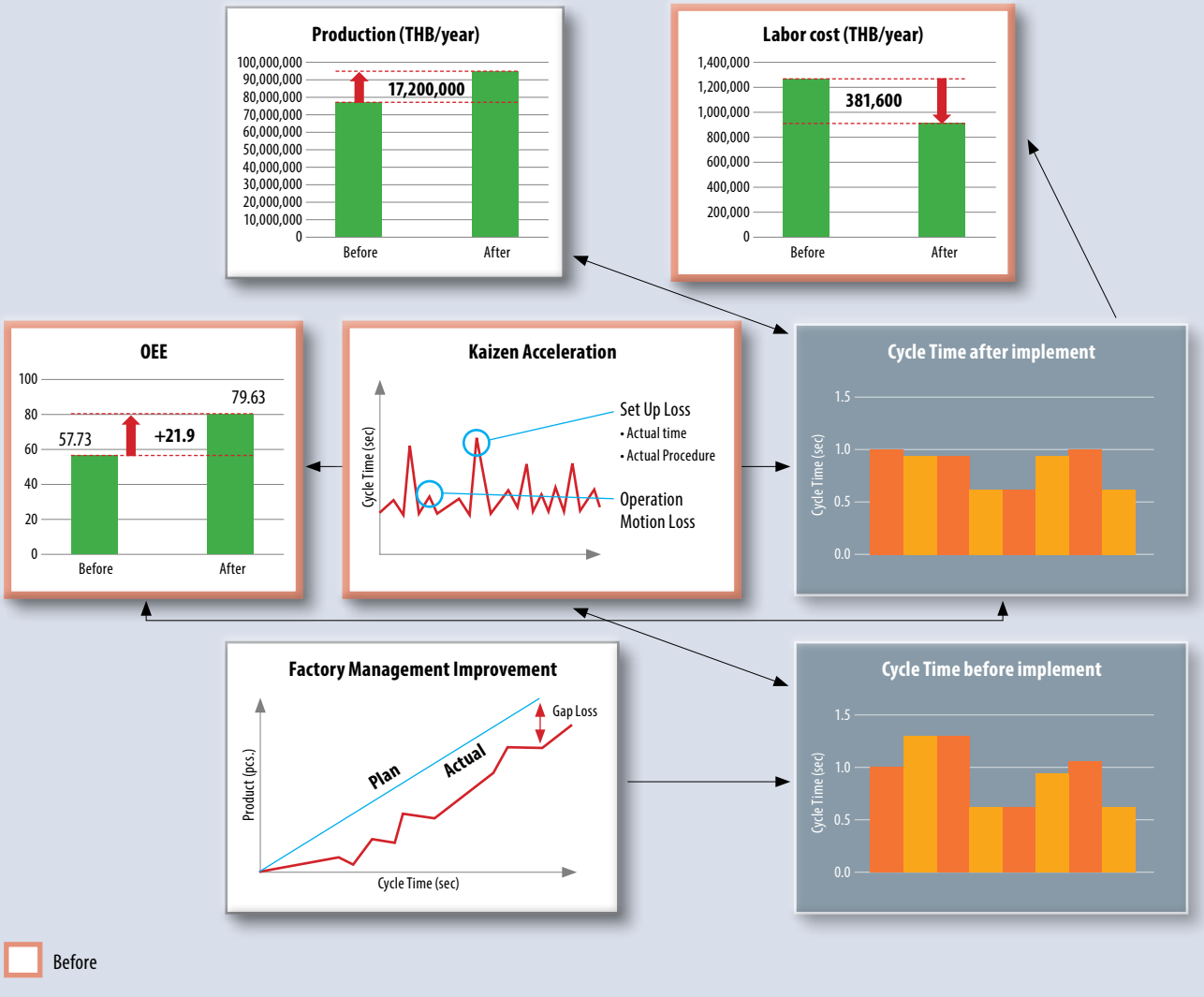
The King's Stella Project Base leads to the productivity improvement in the gel production line in terms the Internal Processes perspective.

- The automatic gel filling machine was applied to increase the production speed by 23%
- The label printing at the cap was modified and turntables used to cut off some processes. It reduced the number of employees from nine to six persons

From the Learning and Growth perspective, King's Stella learnt how to use machine monitoring tools, visualize craftsmanship tools, overall equipment effectiveness (OEE) tools, and line balancing tools.

FIGURE 6.22

KING'S STELLA STRATEGY DYNAMICS FOR QUANTIFIED PERFORMANCE OVER TIME



Step 2: Evaluation based on strategy dynamics for quantified performance over time

King's Stella's objective is to increase productivity. Production cost and OEE are the quantified performance over time. To know the current performance of the production line, technology was used to monitor and find the bottlenecks, which was identified to be the gel filling process. If King's Stella continues with the project, it is estimated that it could benefit more than THB18 million per year.

In the future, King's Stella can apply the technology to other processes and solve other newly identified bottlenecks. However, the key factor to decision-making is on the number of manpower that can be reduced and increasing the speed of production. Also, it is important to retain skilled labors or technicians who are involved in this process as they have learnt the know-how.

Figure 6.18 shows the company data of King's Stella Laboratory Co., Ltd's increased net profit though the trend is only seen to be steady from 2018–19 which indicates that Industry 4.0 is necessary to reduce the cost of production.

Step 3: Evaluation based on qualitative factors and improved performance

In addition to performance over time, there are other meaningful qualitative factors:

- Increase product quality by improving gel level monitoring sensors
- Reduce machine downtime
- Reduce customer waiting time

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The first phase of improvement achieved its objective. However, the technology can be reapplied to other processes for continuous improvement.

FIGURE 6.23

VISUALIZE CRAFTMANSHIP FOR KING'S STELLA PRODUCTION LINE

FIGURE 6.24

DATA ANALYSIS SHOWING THE BOTTLENECK AND KAIZEN MEETING TO IMPROVE PRODUCTIVITY

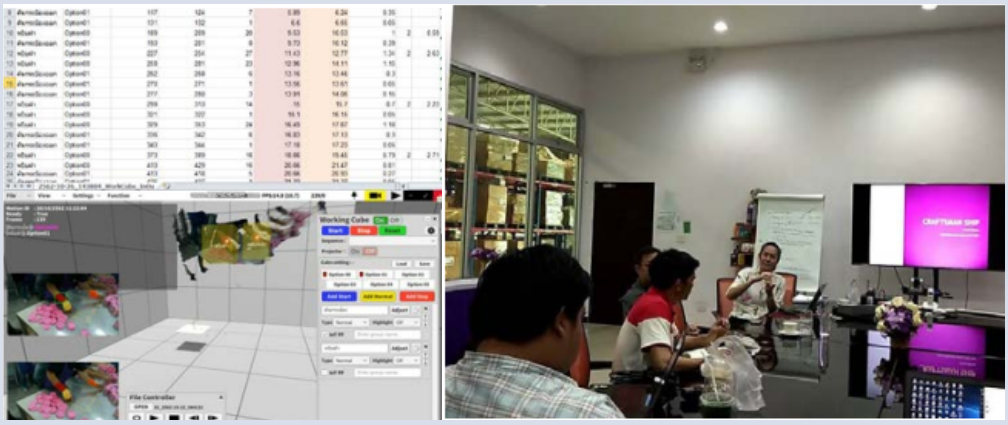


FIGURE 6.25

AUTOMATIC GEL FILLING MACHINE WAS INSTALLED TO IMPROVE PRODUCTIVITY

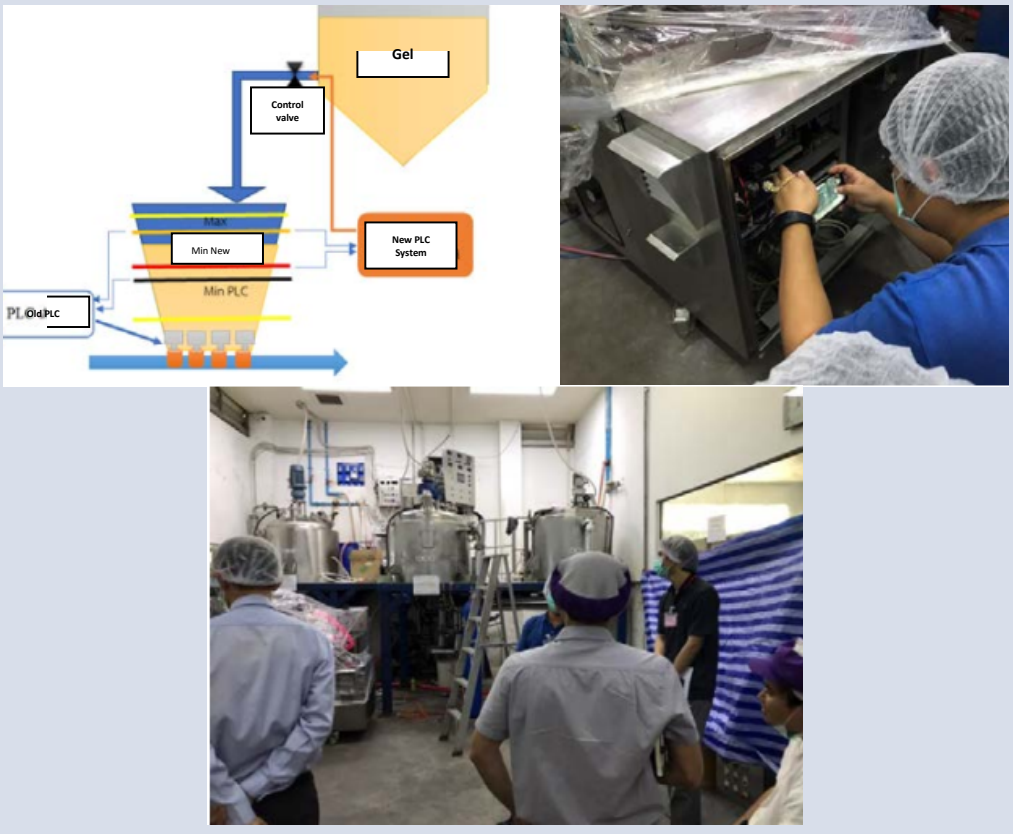
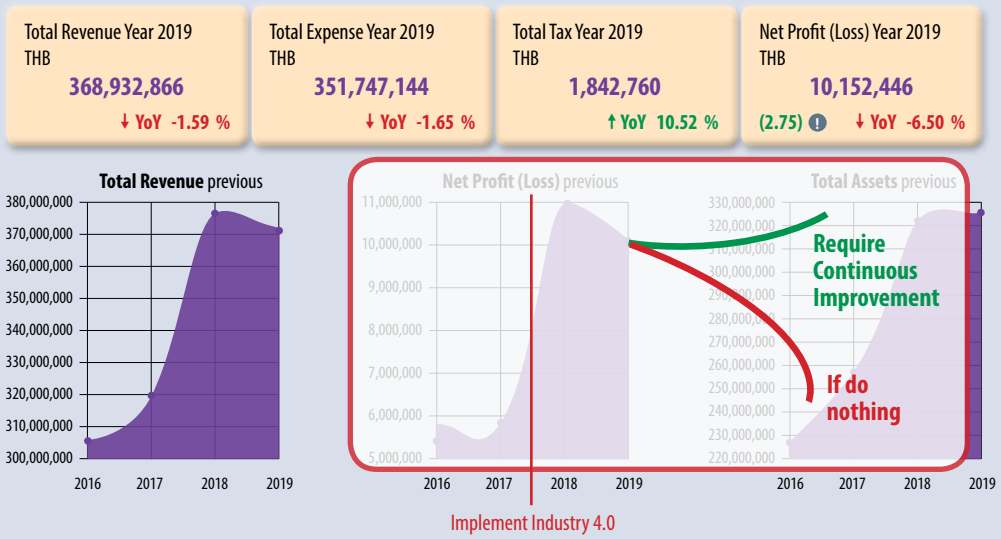


FIGURE 6.26

KING'S STELLA LABORATORY'S PERFORMANCE GAP FOR NET PROFIT



Source: Creden Credit Score (https://creden.co/).

The net profit increased after implementing Industry 4.0 but it dropped when King's Stella did not follow-up in 2019. Thus Kaizen team needs to improve the production line continuously to gain more net profit.

Analysis of Case Study 2: L&E Manufacturing Co., Ltd.

Step 1: Evaluation based on BSC strategy map for diverse performance indicators

L&E has used the machine monitoring technology to find the overall equipment effectiveness (OEE). After using the OEE tools, the bottleneck was identified to be at the process taking place at the arc machine. The team acted by making two sets of automatic feeders to reduce waiting time and balance the production line.

From the Financial perspective, the improvement can increase productivity which simultaneously raises product sales to THB4.8 million per year.

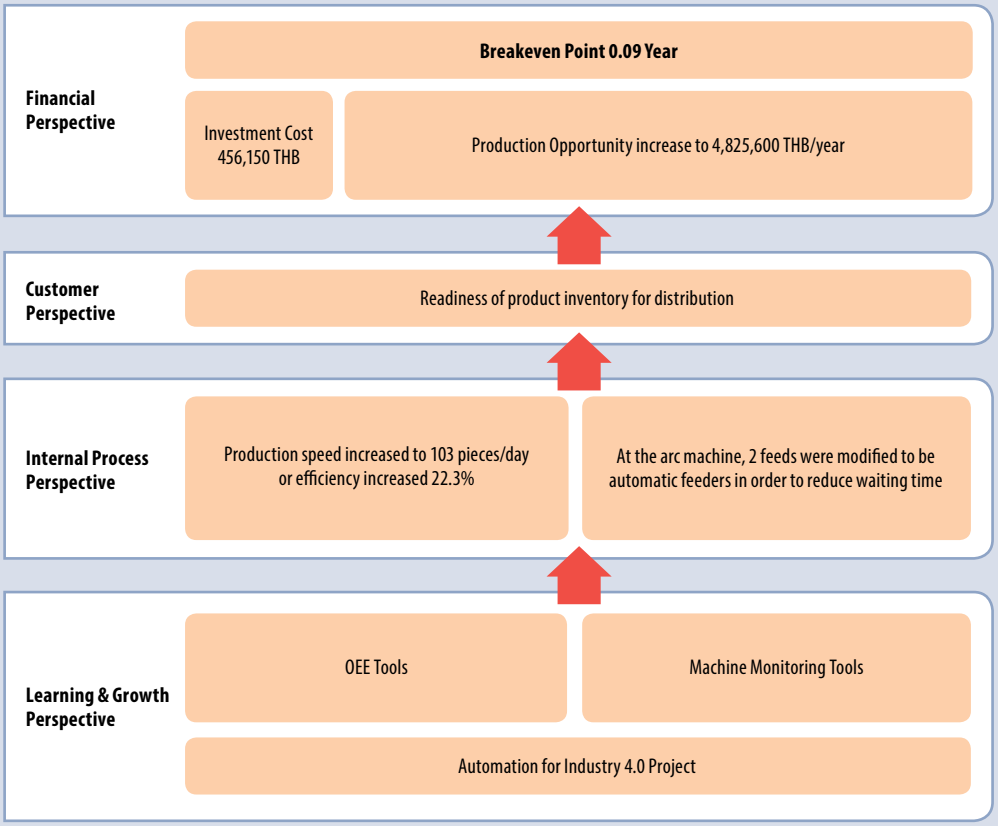
From the Customer perspective, L&E has ability to produce products faster due to the increase in productivity, making it possible for customers to save their inventory cost.

In terms of the Internal Processes perspective, L&E created two automatic feeders at the arc machine to make the product process flows smoothly. This improvement reduced waiting time and increased the production rate to 22.3% or 103 pcs/day.

The Learning and Growth perspective shows that L&E can learn how to use machine monitoring and OEE tools.

FIGURE 6.27

L&E STRATEGY MAP



Step 2: Evaluation based on strategy dynamics for quantified performance over time

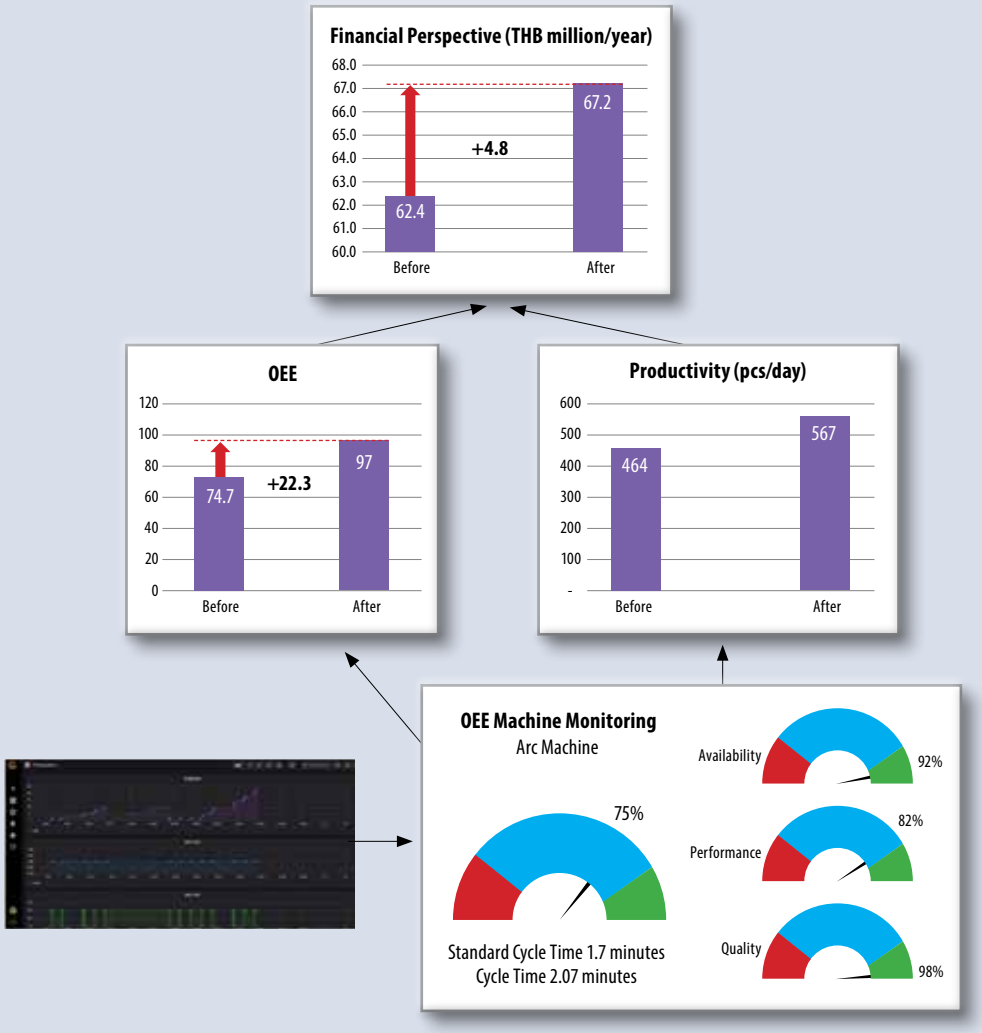
Like King's Stella, the objective of L&E is to increase productivity. Production cost and OEE are the quantified performance over time. To know the current performance, technology was used to monitor and identify bottlenecks which was found to be at the arc machine. If L&E continues the project, it can probably benefit the company with more than THB4.8 million per year.

In the future, L&E can apply the technology to other processes and identify and solve new bottlenecks. However, the key factor to decision-making is the number of manpower that can be reduced and the increase in production speed. Also, it is important to retain skilled labors or technicians who are involved in this process as they have learned the know-how.

Figure 6.19 highlights the company data of L&E, presenting the net profit of this company that increased only for a year and falling back in 2019.

FIGURE 6.28

L&E STRATEGY DYNAMICS FOR QUANTIFIED PERFORMANCE OVER TIME



Step 3: Evaluation based on qualitative factors and improved performance

Besides the performance over time, there are other meaningful qualitative factors:

- Increase machine speed and make the product faster to 0.38 mins/pc
- Produce more than 103 pieces of product a day
- Reduce customer waiting time
- Labor productivity increases by 22.3%

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The first phase of improvement achieved its objective. However, the technology can be reapplied to other processes for continuous improvement.

FIGURE 6.29

MACHINE MONITORING SYSTEM FOR L&E PRODUCTION LINE

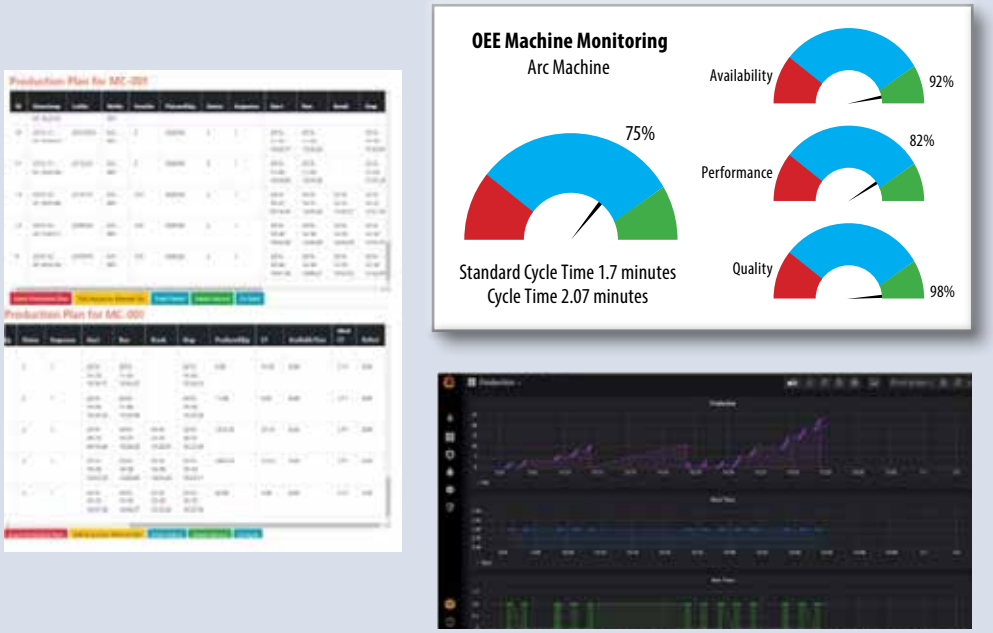
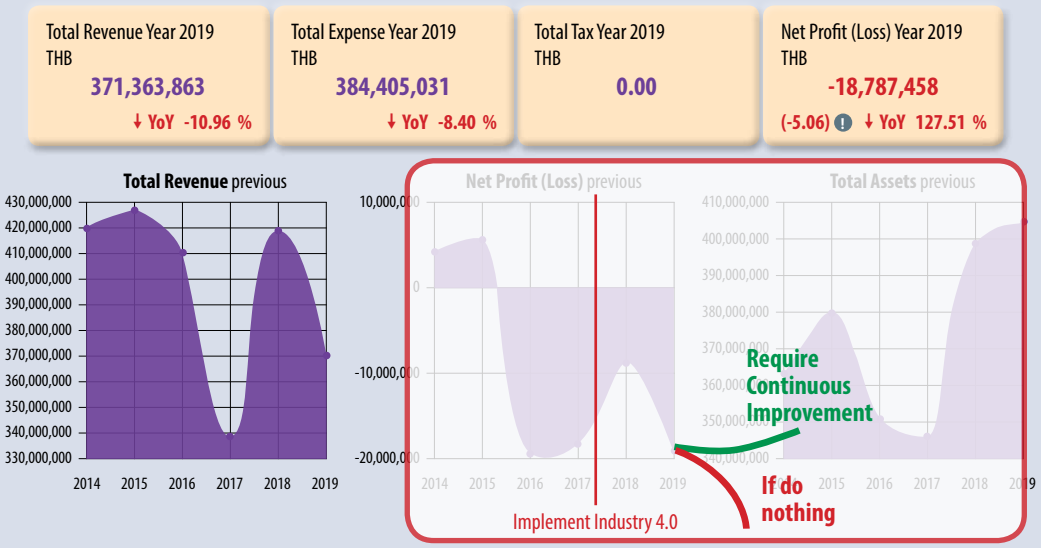


FIGURE 6.30

AUTOMATIC FEEDER FOR ARC MACHINE IN L&E

FIGURE 6.31

L&E'S PERFORMANCE GAP FOR NET PROFIT



Source: Creden Credit Score (https://creden.co/).

The net profit increased after implementing Industry 4.0 but it dropped due to drop in sales in 2019. Thus L&E needs to apply more Industry 4.0 technologies to improve productivity and gain more net profit.

Analysis of Case Study 3: Chong Thai Rung Ruang Co., Ltd.

Step 1: Evaluation based on BSC strategy map for diverse performance indicators

CTR has used the machine monitoring technology to find OEE. After using the OEE tools, the bottleneck of process was identified at the vertical machine center (VMC). The team studied the machine operation and found that the time taken to setup the tools was too long thus an auto presetter was made to increase productivity, reduce defects, and reduce labor cost.

Based on the Financial perspective, the improvement can increase productivity that in turn raises product sales to THB4.6 million per year.

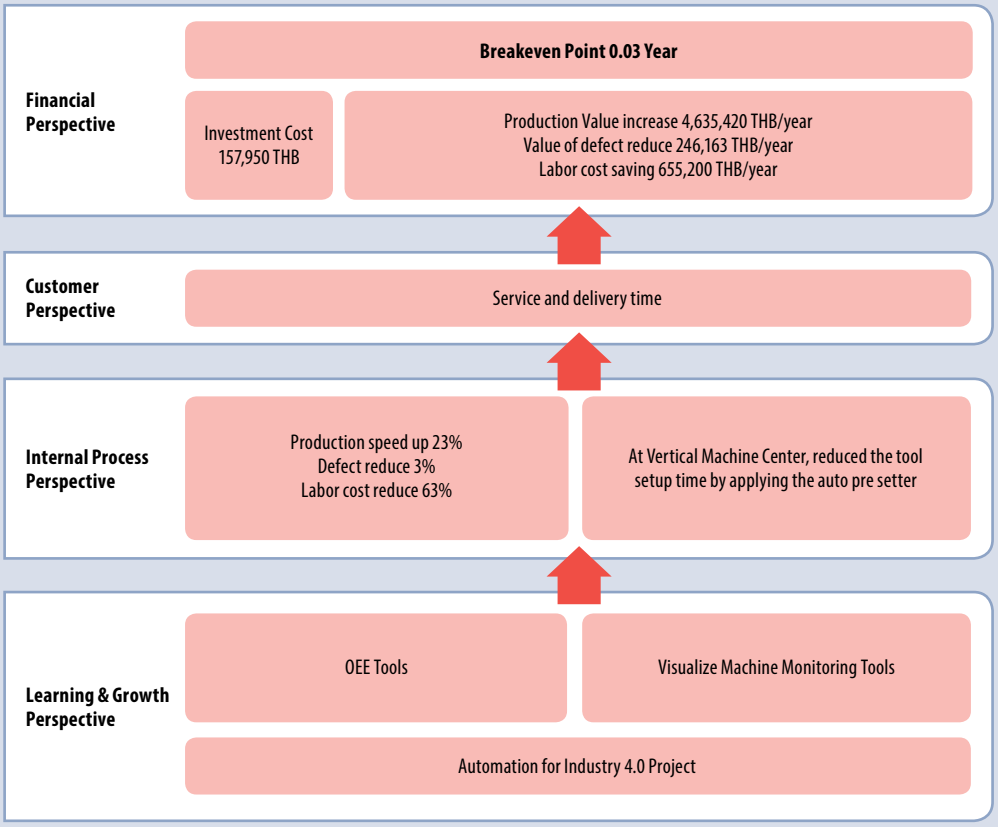
The Customer perspective sees CTR having the ability to produce faster due to the increase in productivity, making it possible for customers to save their inventory cost.

From the Internal Processes perspective, CTR created the auto presetter in the VCM that increased production speed by 20%, reduced the number of defects during tool setting process by 3%, and reduced labor cost by 63%.

On the Learning and Growth perspective, it showed that CTR can learn to use machine monitoring tools and OEE tools.

FIGURE 6.32

CTR STRATEGY MAP



Step 2: Evaluation based on strategy dynamics for quantified performance over time

Like the other case studies, the objective of CTR is to increase productivity. Production cost and OEE are the quantifier of performance over time. In order to know the status of current performance, technology was used to monitor and find the bottleneck in the process. It was identified to be at the VMC. The time wasted from tool setup can be reduced by using the auto prosetter. If CTR continues with the project, it can probably benefit the company with more than THB4.6 million per year. It also saves time and labor costs for the technician to change the tools.

In the future, CTR can apply the technology to other processes and to identify and solve new bottlenecks. However, the key factor to decision-making is on the number of manpower that can be reduced and the increase in production speed. Also, it is important to retain skilled labors or technicians who are involved in this process as they have learned the know-how.

Figure 6.20 shows CTR's company data on the its net profit growth after implementing Industry 4.0 project.

FIGURE 6.33

CTR STRATEGY DYNAMICS FOR QUANTIFIED PERFORMANCE OVER TIME

Step 3: Evaluation based on qualitative factors and improved performance

Beside the performance over time, there are other meaningful qualitative factors:

- Defects from bad cutting tools was reduced to 3%
- Production speed increased by 23%
- Setup time was reduced
- Labor productivity increased by 63%

FIGURE 6.34

MACHINE MONITORING SYSTEM IN CTR

FIGURE 6.35

AUTOMATIC PRESETTER

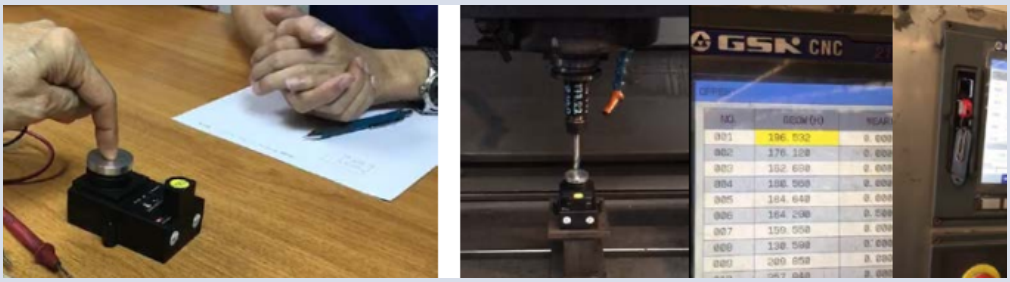
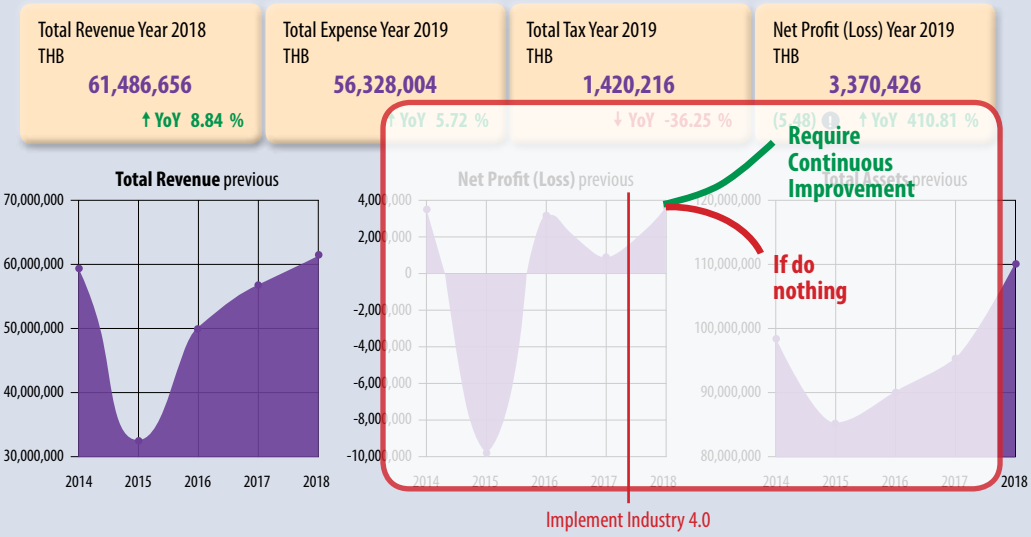


FIGURE 6.36

CTR'S PERFORMANCE GAP FOR THE NET PROFIT



Source: Creden Credit Score (https://creden.co/).

Step 4: Evaluation based on performance gap and reflections for continuous improvement

The first phase of improvement achieved its objective. However, the CTR process is a make-to-order production, making the automatic tool presetter dependent on the product, and it needs to be further developed for continuous improvement.

The net profit increased after implementing Industry 4.0. CTR needs to apply more Industry 4.0 technologies to improve productivity and get more profit. If CTR does nothing, the profit margin would decline.

CONCLUSION

Policy Level

Industry 4.0 has become a part of the manufacturing transformation for the Thai industry. This is more so during the COVID-19 outbreak when the Thai industries are forced to survive by cost reduction and productivity improvement in order to maintain cash flow that had decreased from a huge drop in sales. However, Industry 4.0 needs high investment and only large or medium-large enterprises can afford the cost. In 2018, MOI collaborated with METI of Japan under the "Connected Industry" Scheme. It produced a project called the "3-Stage Pocket Approach". It was initiated with the cooperation of Japanese private companies, Thai universities, Thai research institutes, and DIP. The objective of this project is to strategically transfer Industry 4.0 technology or Connected Industry to Thai SMEs, especially in the manufacturing sector. A key success factor to apply Industry 4.0 to Thai SMEs is to financially prove that such technologies can provide return on investment within a few years. Also, soft loans with very low interest rate can be another factor to attract SMEs to invest in Industry 4.0 technologies.

Enterprise Level

Three case studies were selected from 1,000 companies that joined the 3-Stage Rocket Approach program in 2018–19 and presented in this paper.

From the interviews on the focus group, the top managements in all three case studies paid attention to the development of technology that will increase the competitiveness of production in the market. Production cost and OEE are the performance quantifier over time and the strategy map is used to study the manufacturing transformation. The cases have utilized a technology called the machine monitoring system and visualization of craftsmanship to monitor the production line. The manufacturing data were gathered in real time and analyzed by experts. The Kaizen team studied the data and identified the bottlenecks. Talent teams developed the productivity improvement projects such as the machine automation or automatic jigs and fixtures to reduce the processing process and create a production balance. From the Financial perspective, automation can reduce the number of manpower and increase the production rate, to reduce production cost, increase OEE, and create opportunities to ship products on time.

Strategic business is seen to reduce the production cost in SMEs that are not aggressive in laying off their workforces. Looking at the Internal Process perspective, it shows that the SMEs from the case studies prefer to implement Industry 4.0 step-by-step. Change of technology and cost of robot and automation are the driving force in investments on the production improvement project.

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LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AGV	- Autonomous guided vehicle
AI	- Artificial intelligence
AICTE	- All India Council for Technical Education
AIST	- National Institute of Advanced Industrial Science and Technology
AR	- Augmented reality
ATAL	- AICTE Training & Learning Academy
B2C	- Business-to-customer
BSC	- Balanced Scorecard
BSE	- Bombay Stock Exchange
CAGR	- Compound annual growth rate
CII	- Confederation of Indian Industry
CMTI	- Central Manufacturing Technology Institute
CNC	- Computer numerical control
Cobots	- Collaborative robots
COE	- Center of Excellence
CPS	- Cyber-physical systems
CSTI	- Council for Science, Technology, and Innovation
CTI	- Castings Technology International
DHI	- Department of Heavy Industries
DIP	- Department of Industrial Promotion
DIW	- Department of Industrial Works
DOSM	- Department of Statistics Malaysia
ECU	- Engine control units
EEC	- Eastern Economic Corridor
EMS	- Electronics Manufacturing Services
ERP	- Enterprise resource planning
ESG	- Environment, social, and governance
FDI	- Foreign direct investment
FMM	- Federation of Malaysian Manufacturers
FTI	- Federation of Thai Industries
HEC	- Heavy Engineering Corporation
IC	- Integrated circuit
IISc	- Indian Institute of Science
IIT	- Indian Institute of Technology
Industry4WRD	- National Policy on Industry 4.0
IoT	- Internet of Things
IPC	- International Patent Classification
ITC	- Industry Transformation Center
ITRI	- Industrial Technology Research Institute
KLCI	- Kuala Lumpur Composite Index
M&E	- Machinery and equipment
MATRADE	- Malaysia External Trade Development Corporation

MeitY	- Ministry of Electronics & Information Technology
MES	- Manufacturing execution systems
METI	- Ministry of Economy, Trade, and Industry
MIDA	- Malaysia Investment Development Authority
MOEA	- Ministry of Economic Affairs
MOI	- Ministry of Industry
MSME	- Micro, small, and medium enterprises
MTO	- Make-to-order
NASSCOM	- National Association of Software and Service Companies
NEDO	- New Energy and Industrial Technology Development Organization
NSTDA	- National Science and Technology Development Agency
OEE	- Overall equipment effectiveness
OIE	- Office of Industrial Economics
OSMEP	- Office of Small and Medium Enterprise Promotion
PAT	- Profit after tax
PBT	- Profit before tax
PMC	- Precision Machinery Research & Development Center
PR China	- People's Republic of China
PSDC	- Penang Skills Development Centre
QC	- Quality control
QCT	- Quality, cost, and time
RFID	- Radio frequency identification
ROC	- Republic of China
ROI	- Return of investment
ROIC	- Return on invested capital
ROK	- Republic of Korea
SAMARTH	- Smart Advanced Manufacturing and Rapid Transformation Hub
SDGs	- Sustainable Development Goals
SiTARC	- Scientific and Industrial Testing and Research Centre
SMB	- Smart machine box
SMEs	- Small and medium enterprises
SMT	- Surface-mount technology
STEM	- Science, technology, engineering, and mathematics
TAF	- Taiwan Accreditation Foundation
TIFAC	- Technology Information, Forecasting and Assessment Council
TPM	- Total Productive Maintenance
TRL	- Technology Readiness Level
TSMC	- Taiwan Semiconductor Manufacturing Co.
VMC	- Vertical machine center
VR	- Virtual reality
WEF	- World Economic Forum
y-o-y	- Year-on-year

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TRANSFORMING MANUFACTURING

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