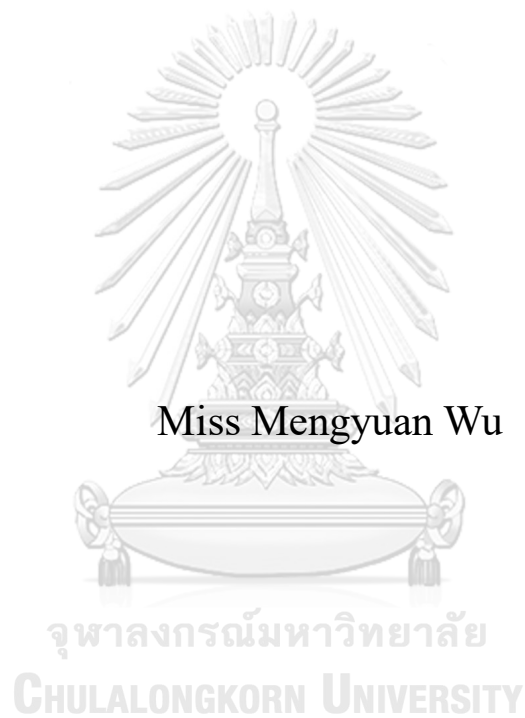


Impact of Implementing Lean Six Sigma on Profitability - A  
case study of BJC's Glass Packaging Division



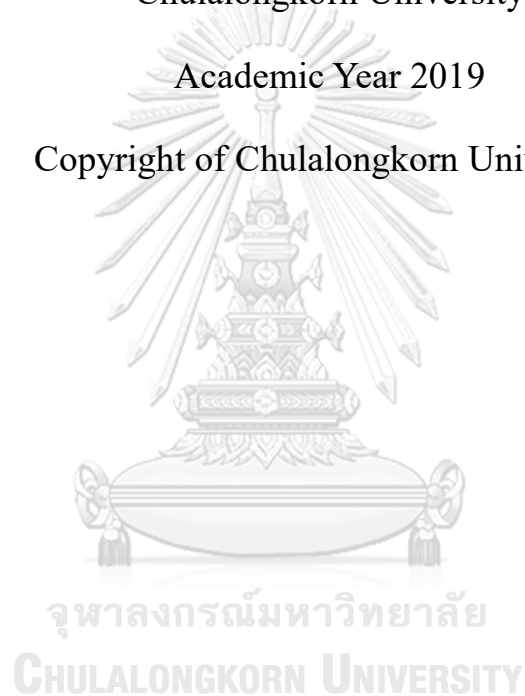
An Independent Study Submitted in Partial Fulfillment of the  
Requirements  
for the Degree of Master of Arts in Business and Managerial Economics  
Field of Study of Business and Managerial Economics

FACULTY OF ECONOMICS

Chulalongkorn University

Academic Year 2019

Copyright of Chulalongkorn University



จุฬาลงกรณ์มหาวิทยาลัย

CHULALONGKORN UNIVERSITY

-



น.ส.เหมิงหยวน อู่

จุฬาลงกรณ์มหาวิทยาลัย

CHULALONGKORN UNIVERSITY

สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตร

มหาบัณฑิต

สาขาวิชาเศรษฐศาสตร์ธุรกิจและการจัดการ

สาขาวิชาเศรษฐศาสตร์ธุรกิจและการจัดการ

คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2562

ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย



จุฬาลงกรณ์มหาวิทยาลัย  
**CHULALONGKORN UNIVERSITY**



เหมิงหยวน อู๋ : . ( Impact of Implementing Lean Six Sigma on Profitability

- A case study of BJC's Glass Packaging Division) อ.ที่ปรึกษาหลัก : ชัยรัตน์

เอี่ยมกุลวัฒน์



สาขาวิชา	เศรษฐศาสตร์ธุรกิจและการจัด	ลายมือชื่อนิสิต .....
	การ	...
ปีการศึกษา	2562	ลายมือชื่อ
า		อ.ที่ปรึกษาหลัก .....

# # 6284081229 : MAJOR BUSINESS AND MANAGERIAL ECONOMICS

KEYWOR Lean Six Sigma, DMAIC, Critical success factors, Profitability,

D: BJC's Glass Packaging Division

Mengyuan Wu : Impact of Implementing Lean Six Sigma on Profitability  
- A case study of BJC's Glass Packaging Division. Advisor: Assoc. Prof.  
CHAIRAT AEMKULWAT, Ph.D.

The objective of this paper is to assess the impact of implementing LSS in manufacturing glass packaging on profitability in BJC's glass packaging division, and to explore the CSFs for implementation of LSS in BJC context. Also, described the industry trend of implementing LSS in the future. Line chart and pie chart is used to display and analyze the company's relevant data from 2006-2019 and the operating profit ratio, ratio of profits to cost and expense (RPCE), and return on total assets ratio (ROA) are will be calculated and analyzed to assess the impact of implementing LSS on profitability of BJC's glass packaging division. The literature review of CSFs is combined with the actual situation of BJC's glass packaging division to explore the CSFs for implementation of LSS in BJC context. The expert viewpoints are be used to describe the industry trend of implementing LSS in the future. Implementation of LSS by the BJC's glass packaging division has achieved huge returns in the first year, but due to the lack of sustainability, the long-term impact of the project on the company is not sustained. Long-term involvement and commitment of management are critical to the implementation of the LSS program. During the financial crisis LSS helps the leader's job easier. Due to the coming era of big data, how to obtain value from big data is a major challenge to LSS. At the same time, the unique advantages of LSS in informatization and intelligence will make LSS have more and more application space in the future. The results of this research will have implications for BJC considering further improvements in profitability through the implementation of LSS. The findings will provide guidance for BJC to implement LSS more effectively in the future. And this research will provide future development direction for BJC's glass packaging division.

Field of Study:	Business and Managerial Economics	Student's Signature .....
Academic Year:	2019	Advisor's Signature .....

## ACKNOWLEDGEMENTS

Many people have offered me valuable help in my research paper writing, including my advisor, my lecturers, my classmates and my parents.

Firstly, I would like to give my sincere gratitude to Prof. Chairat Aemkulwat, my advisor who with extraordinary patience and consistent encouragement, gave me great help by providing me with necessary materials, advice of great value and inspiration of new ideas. It is his suggestions that draw my attention to a number of deficiencies and make many things clearer. Without his strong support, this research paper could not be the present form. My heartfelt thanks also go to Prof. Jessica Vechbanyongratana and Prof. Yong Yoon, my lecturers of Research Methods and Workshop in Business and Managerial Economics course, for their help in the making of this research paper as well as their enlightening lectures from which I have benefited a great deal.

Then, I pleased to acknowledge my classmates for their invaluable assistance throughout the preparation of the original manuscript. They graciously make considerable comments and sound suggestions to the outline of this paper. Finally, in particular, I would like to express my gratitude to my parents for their support, they provided the computers for me to search for information. It is of great help for me to finish this research paper successfully.

Mengyuan Wu



---

## TABLE OF CONTENTS

	<b>Page</b>
ABSTRACT (THAI) .....	iii
ABSTRACT (ENGLISH).....	iv
ACKNOWLEDGEMENTS .....	v
TABLE OF CONTENTS .....	vi
LIST OF TABLES .....	viii
LIST OF FIGURES .....	ix
Executive Summary.....	1
1. Introduction .....	3
1.1 Company Background and Concept .....	3
1.2 Research Question.....	6
1.3 Research Objectives .....	6
1.4 Scope of the Study .....	6
1.5 Possible Benefits.....	7
2. Methodology and Data Gathering Process.....	7
3. Production Significant .....	8
3.1 Significance of packaging supply chain.....	8
3.2 Significance of glass packaging.....	9
4. DMAIC Methodology of LSS in Manufacturing Company .....	10
5. DMAIC Methodology of LSS in Manufacturing Company Glass Packaging.....	11
5.1 LSS Define phase.....	11
5.2 LSS Measure phase .....	12
5.3 LSS Analysis phase.....	13
5.4 LSS Improve phase .....	14

---

5.5 LSS Control phase .....	15
6. Key Ratios Analysis.....	15
6.1 Sales (million baht) .....	16
6.2 Expense (million baht) .....	17
6.3 Profit before tax and Net profit (million baht).....	18
6.4 Total assets (million baht).....	19
6.5 Operating profit ratio.....	19
6.6 RPCE.....	20
6.7 Return on total assets ratio (ROA).....	21
7. CSFs of Implementing LSS in BJC's Glass Packaging Division.....	23
8. Industry Trend .....	26
9. Conclusion.....	27
10. Recommendation .....	29
REFERENCES.....	31
VITA.....	34

---

## LIST OF TABLES

	<b>Page</b>
<i>Table 1 Sigma Level</i> .....	4
<i>Table 2 Waste categorization</i> .....	13
<i>Table 3 Cause validation</i> .....	14
<i>Table 4 Control Plan</i> .....	15
<i>Table 5 Summary of CSFs</i> .....	24



---

## LIST OF FIGURES

	<b>Page</b>
<i>Figure 1 Revenue Structure of BJC Group in.....</i>	8
<i>Figure 2 Revenue Structure of BJC Group in 2016 .....</i>	9
<i>Figure 3 Flowchart of glass packaging manufacture process.....</i>	11
<i>Figure 4 Blow and Blow Process.....</i>	11
<i>Figure 5 Cause-and-effect diagram.....</i>	13
<i>Figure 6 Increase in production output after LSS .....</i>	16
<i>Figure 7 Sale of BJC's glass packaging division from 2006 to 2019 .....</i>	16
<i>Figure 8 Expense of BJC's glass packaging division from 2006 to 2019 .....</i>	17
<i>Figure 9 Profit before tax and net profit of BJC's glass packaging division from 2006 to 2019 .....</i>	18
<i>Figure 10 Total assets of BJC's glass packaging division from 2006 to 2019 .</i>	19
<i>Figure 11 Operating profit ratio from 2006 to 2019.....</i>	20
<i>Figure 12 RPCE from 2006 to 2019 .....</i>	21
<i>Figure 13 ROA from 2006 to 2019.....</i>	22

---

## Executive Summary

Due to the increasingly fierce market competition, enterprises in the manufacturing industry are looking for ways to improve production and management processes to maintain market competitiveness. This requires manufacturing enterprises to continuously improve productivity, reduce production costs, and continuously improve product quality. BJC's glass packaging division has been working hard to increase efficiency and productivity to reduce production costs and improve the quality of products through various standardized systems, including LSS. LSS is a combination of Lean Production and Six Sigma management, essence is to eliminate waste. It is considered to be an advanced method to reduce product costs, improve product quality, and maximize customs satisfaction.

BJC's glass packaging division started implementing LSS in 2010. In define phase, through the analysis of manufacturing process of glass packing by using flowchart, based on customer feedback and production practices, experts in the BJC's glass packaging division identified quality defects in glass packaging which is bursting of the neck and mouth of glass bottles always occurred in the blow and blow process, will cause leakage after pressing the glass bottle cap. In measure phase, seven types of waste are classified by its impact on product manufacturing, and confirmed that the quality defects of bottle mouth and bottle neck bursting will cause waste of rework, result in production cost increase and waste of time. In analysis phase, cause-and-effect diagram is used to define the actual source of these defect. Indicated that jaw arm, die, scissors, blowing machine and processing technology are five sources of these defect. In improve phase, the significance of each possible cause is verified, and suggestions for improvement for each significant cause is proposed. In control phase, various LSS tools are used to implement process control which are control charts, poka-yoke, Kanban and 5S. After the implementation of LSS in the BJC's glass packaging division, the annual output of glass packaging increased by 12%.

In order to assess the impact of the implementation of LSS on the company's profitability, this research is conducted. There are three objective of this research which are firstly, to assess the impact of the implementation of LSS on the company's profitability; secondly, to explore the CSFs for implementation of LSS in BJC context; lastly, to describe the industry trend of implementing LSS in the future.

To assess the impact, line chart is used to display and analyze the company's relevant data from 2006-2019. Operating profit ratio, ratio of profits to cost and expense (RPCE), and return on total assets ratio (ROA) are used as analysis indicators for profitability. Secondary data from annual report and financial statements from 2006 to 2019 that BJC published in website is used to calculate and analyze these indicators. Through the analysis of the profitability of the division before and after the

implementation of LSS, the results show that operating profit ratio increased by 164.53%, ratio of profits to cost and expense increased by 191.47%, return on total assets ratio increased by 111.32% in 2010, but all of them continued to decline in 2011 and 2012, which can be interpreted that the implementation of LSS by the BJC's glass packaging division has achieved huge returns in the first year, but due to the lack of sustainability, the long-term impact of the LSS program on the company is not sustained.

For this result, based on literatures review, this research summarizes the CSFs for implementing LSS and the barriers and challenges in implementing LSS. Then, combined with the actual situation of the division, three CSFs of the implementation of LSS in BJC context are proposed which are long-term involvement and commitment of management, rigorous project supervision and detailed project report, and based on the actual situation of the business itself to implement LSS.

At the end of this research, based on the viewpoint of the industry experts, the future trends of LSS in the manufacturing industry are described. During the financial crisis, leaders and organizations viewed LSS as a way to reduce costs and maintain cash flow because LSS method provides concepts, methods, and tools for change and continuous improvement. This makes the leader's job easier. In additional, the era of big data is coming, it also has a great impact on traditional manufacturing, how to obtain value from big data is a major challenge to LSS in the future. At the same time, the unique advantages of LSS in informatization and intelligence will make LSS have more and more application space in the future.

Based on the above research and analysis, recommendations for improvement of the BJC's glass packaging division were proposed. Hopefully, this research will have implications for BJC considering further improvements in profitability through the implementation of LSS, will help BJC to implement LSS more effectively in the future, and provide future development direction for BJC Group.

## 1. Introduction

### 1.1 Company Background and Concept

#### 1.1.1 Company Background

Berli Jucker Co., Ltd. or BJC is a group with a long history. In 1882, during the reign of King Chulalongkorn Rama V, two Swiss businessmen, Mr. Albert Jucker and Mr. Henry Sigg established Jucker and Sigg and Co in Siam to sell miscellaneous goods, also import household products to Siam and to export teakwood out of Siam to other countries. In 1948, Berli Jucker and Co opened a soap factory near Wat Plubplachai with the new partners Mr. Walther Miner, a Swiss, and Mr. Gustav Heitman, a German, thus expanding the business to manufacturing. In 1951, Rubia Industry Co., Ltd. was established in order to produce a new brands of fragrance soap called “Parrot Fragrance soap” and “Rosette Fragrance soap”. The company also established a glassware factory in the same year, which has been operated by Thai Glass Industries PCL till now. Berli Jucker was listed on the Thai stock market on April 25, 1975 and is one of the seven starting members of the exchange. In 1992, the company changed its name to Berli Jucker PCL. In 2010, the company partnered with Owens-Illinois Inc. to acquire Malaya Glass, a large-scale manufacturer of glass packaging in Southeast Asia. The plant's production bases are located in Thailand, China, Vietnam and Malaysia. The acquisition makes the company became the largest glass manufacturer in Southeast Asia. The company developed a glass packaging manufacturing plant in 2015 and successfully produced green glass bottles using amber broken glass.

Nowadays, Berli Jucker PCL has a lot of business units include packaging supply chain, consumer supply chain, healthcare and technical supply chain, modern retail supply chain and other business units. This research will focus on glass packaging division of packaging supply chain.

BJC's Glass Packaging Division in Thailand products glass bottles and containers for various industries, including beer, whiskey, wine, drinking water, soda, soft drinks, energy drinks, food and medicine. The glass business group has been working hard to increase efficiency and productivity to reduce production costs and improve the quality of products through various standardized systems, including LSS. In addition, training institutions were opened to develop knowledge about glass products, production technology of glass packaging products. The purpose of these activities is to compete in the domestic and foreign markets and to become a leader in the glass packaging industry in the region.

### 1.1.2 Concept of Lean Six Sigma (LSS)

Due to the increasingly fierce market competition, companies in the manufacturing industry are looking for ways to improve production and management processes to maintain market competitiveness. This requires manufacturing enterprises to continuously improve productivity, reduce production costs, and continuously improve product quality. At present, the improvement methods received by the industry mainly include total quality management (TQM), total preventive maintenance (TPM), lean production and six sigma theories.

The concept of lean production can be traced back to the "Toyota production model" promoted by Toyota Motor Corporation of Japan in the 1960s. In terms of organization, manage the relation with user, supply chain, product development and production operations, work efficiency and profitability have been greatly improved. Lean production is a production method based on cost and quality. Its purpose is to eliminate waste, improve all the processes, and increase overall productivity. From the perspective of customers, it redefines production value, maximizes profits and maximizes value by minimizing costs through rational use of the company's effective resources. The concept of lean management is value, value flow, flow, pull, and perfect the overall system. Its main idea is to make the production process and product quality perfect in the process of eliminating waste and continuous improvement. There are four main features of lean production methods: firstly, simplify work tools and remove other redundant work. Secondly, pay attention to the play of the main role of employees, so as to maximize their work enthusiasm and initiative. Thirdly, use lean thinking to control the production process. Fourthly, continuous improvement, with the ultimate goal of being perfect.

Six Sigma ( $6\sigma$ ) is a management method. It was proposed by an engineer who worked at Motorola in 1986. It is a statistical evaluation method, focuses not only on product quality, but also on process improvement. " $\sigma$ " is a letter in Greek. It is used to represent the standard deviation value. The measured  $\sigma$  represents defects per million opportunities (DPMO). The larger the value of  $\sigma$ , the less defects or errors.

Sigma level	Sigma	DPMO	Percent defective	Percentage yield
1	-0.5	691,462	69%	31%
2	0.5	308,538	31%	69%
3	1.5	66,807	6.7%	93.3%
4	2.5	6,210	0.62%	99.38%
5	3.5	233	0.023%	99.977%
<b>6</b>	<b>4.5</b>	<b>3.4</b>	<b>0.00034%</b>	<b>99.99966%</b>
7	5.5	0.019	0.0000019%	99.9999981%

Table 1 Sigma Level



---

Source: [https://en.wikipedia.org/wiki/Six\\_Sigma#Sigma\\_levels](https://en.wikipedia.org/wiki/Six_Sigma#Sigma_levels)

$6\sigma$  is a goal which means that 99.99966% of all processes and results are defect-free, that is to say, to do 1 million things, only 3.4 of them are defective, which is the most perfect state that human can be achieved.

In a sense, the Six Sigma method and the Lean production method have in common, for example: leadership support is very critical, both belong to improving working methods, all emphasize low input and high output, and take customer needs and satisfaction as the fundamental of enterprise development. However, only when Six Sigma theory and lean production complement each other and effectively combine can truly achieve the effect of one plus one greater than two (Yali, 2017). Therefore, LSS is a combination of Lean Production and Six Sigma management. On the one hand, LSS overcomes the shortcomings of lean production without using quantitative tools to manage the process, on the other hand, it overcomes disadvantages of Six Sigma theory that does not improve the production process, only improves the speed and efficiency of the process or only simplifies the process to reduce the investment in production capital. LSS's essence is to eliminate waste, aims to reduce product costs, improve product quality, provide customers with perfect services and products quickly and in a timely manner, maximize customer satisfaction and maximize product reputation, thereby improving the company's competitive advantage.

At present, LSS is considered to be an advanced method, not only in the manufacturing field, but in recent years, other fields such as the logistics industry, banking, construction engineering, and hospitals have also begun to implement LSS (Yansiyu, 2018). There are generally five phases in the implementation of LSS program which are Define-Measure-Analyze-Improve-Control (DMAIC), through DMAIC, organizational processes can benefit from reducing the variation of business processes; Improving the capability and stability of processes; Reducing process, inventory, and costs; More effectively use resources; Improve customer satisfaction and increase market share. The key to success implementing LSS lies in how to implement and promote this advanced technique. The implementation of LSS should be combined with the actual situation of the company. It cannot be copied from other cases, nor can it have an illusion that it will take effect immediately

### 1.1.3 Concept of Profitability

Profitability is the primary goal of all companies. Without profitability, companies will not survive for long (Yanzhen, 2010). The essence of profitability is the company's revenue. The cost of revenue depends on the cost, price and quantity of the goods sold. Increased costs will reduce profits, the cost may include labor costs,

raw material costs, rental costs, etc. Conversely, if the company can improve productivity by using advanced technique, then profits should increase.

Profitability is mainly reflected in indicators such as operating profit ratio, ratio of profits to cost and expense (RPCE), and return on total assets ratio (ROA). The higher the operating profit rate, the higher the operating profit provided by the company's products sales, and the stronger the profitability of the company; The higher RPCE, the smaller the cost the company pays for profit, the better the cost control, and the stronger the profitability; In general, the higher ROA, the better the asset utilization efficiency of the company and the stronger the profitability of the entire company.

As stated above, profitability is largely affected by unit product production costs and operating costs, the successful implementation of LSS can greatly help eliminate waste and reduce the company's production costs and operating costs. BJC's glass packaging division began to implement LSS in 2010. A lot of human resources, material resources and time have been invested in the program. Is the company's investment in LSS worth it? After 10 years of practice, what has LSS brought to the company? Has the company implemented LSS efficiently? How does the implementation of LSS affect the company's profitability? This research will investigate these issues.

## 1.2 Research Question

The research question of this paper is "What is the impact of implementing LSS in manufacturing glass packaging on profitability in BJC's packaging supply chain?"

## 1.3 Research Objectives

The research objectives of this paper are:

1. To assess the impact of implementing LSS in manufacturing glass packaging on profitability in BJC's glass packaging division.
2. To explore the CSFs for implementation of LSS in BJC context.
3. To describe the industry trend of implementing LSS in the future.

## 1.4 Scope of the Study

BJC's glass packaging division as Thailand's leading glass packaging manufacturer, this study will use BJC's glass packaging division as a case to investigate the impact of implementing LSS on profitability of a company. The company started implementing LSS in 2010, data will be collected from secondary sources such as annual report and financial statements from 2006 to 2019 that BJC published in website, this study will analyze the related data including but not limited to sales, expense and profit changes before (2006-2009) and after (2010-2019)

implementing LSS to find the impact on profitability. According to the definition of CSFs in the implementation of LSS, this means that if these important conditions cannot be met, it is almost impossible to effectively implement LSS. In order to explore the CSFs for implementation of LSS in BJC context, I will review and summarize the relevant literature about implementing LSS in manufacturing industry, and combined with the actual situation of BJC company, put forward feasible recommendations for BJC to implement LSS more effectively. In the past many years, the benefits of implementing LSS for a company are obvious to all, and have been recognized by all circles. In the end, I will review the relevant literature and viewpoint of experts in the industry to describe the future trends of implementing LSS in the manufacturing industry.

### 1.5 Possible Benefits

1. The results of this study will have implications for BJC considering further improvements in profitability through the implementation of LSS.
2. The findings of this study will provide guidance for BJC to implement LSS more effectively in the future.
3. The research will provide future development direction for BJC's glass packaging division.

## 2. Methodology and Data Gathering Process

This study aims to assess the impact of implementing LSS in manufacturing glass packaging on profitability in BJC's glass packaging division, to explore the CSFs for implementation of LSS in BJC context, and to describe the industry trend of implementing LSS in the future. Same as a large number of researches on the impact of LSS, the quantitative data is needed for assessing the impact of implementing LSS, and qualitative data is needed for explore the CSFs for implementation of LSS. The quantitative data include but not limited to sales, expense and profit will be collected from secondary sources such as annual report and financial statements from 2006 to 2019 that BJC published in website. Line chart and pie chart is used to display and analyze the company's relevant data from 2006-2019 and the operating profit ratio, RPCE and ROA are will be calculated and analyzed to assess the impact of implementing LSS on profitability of BJC's glass packaging division. The qualitative data is collected from literature review and viewpoint of experts in the industry. The literatures are searched by using "CSFs for implementing LSS" and "Barriers and challenges in implementing LSS" as keywords in Google Scholar. The literature review is combined with the results of quantitative data analysis to explore the CSFs for implementation of LSS in BJC context and come up with recommendation. The

viewpoint of experts will search in Google and Baidu by using “LSS in the future” and “LSS future trend” as keyword.

### 3. Production Significant

#### 3.1 Significance of packaging supply chain

As a large enterprise, BJC has many business units. Before 2016, the packaging supply chain has been the main source of revenue for the group, accounting for more than 40% of the group's total revenue. (Figure 1)

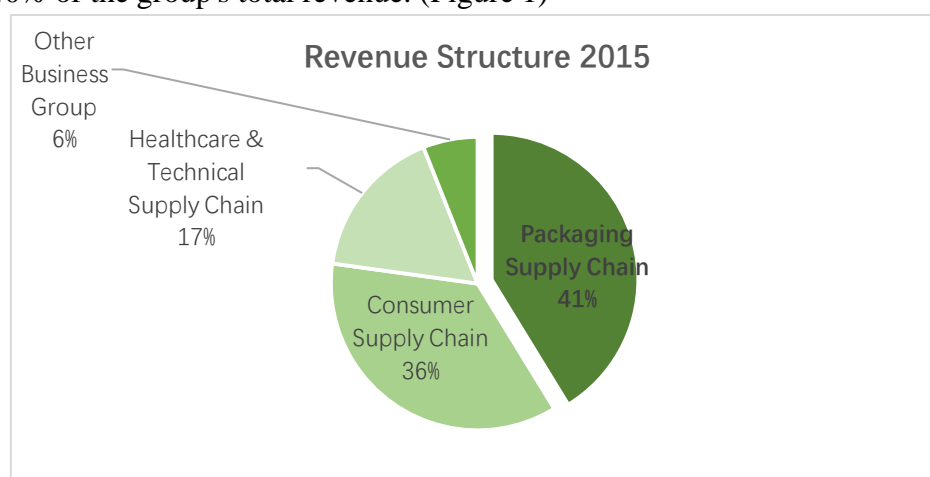


Figure 1 Revenue Structure of BJC Group in

Source: Annual Report of BJC Group

In 2016, BJC Group acquired Big C. Since then, 60% -70% of the group's revenue comes from the modern retail supply chain, but the packaging supply chain is still the group's second largest source of revenue. (Figure 2)

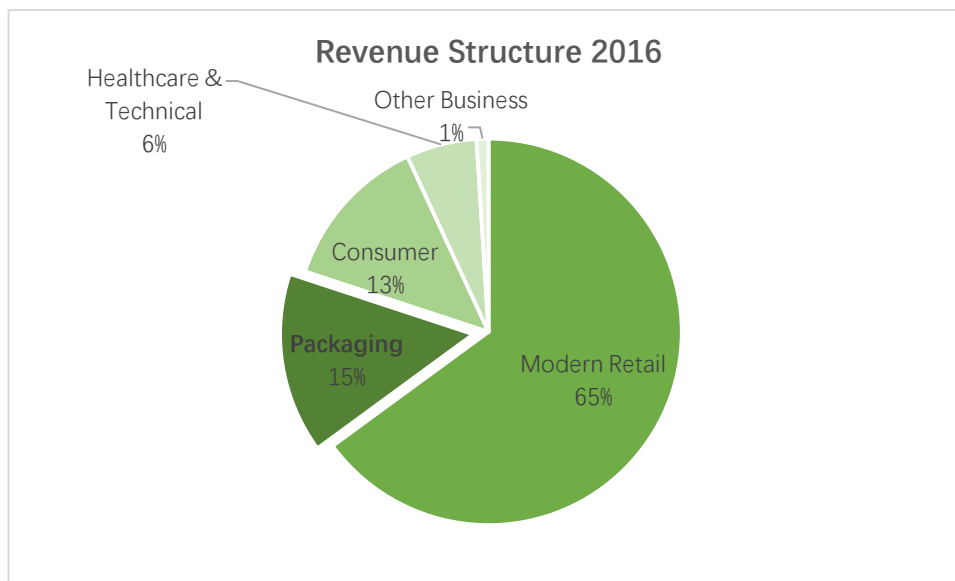


Figure 2 Revenue Structure of BJC Group in 2016

Source: 2016 Annual Report of BJC Group

Therefore, the production of glass packaging has a significant impact on the group's revenue. As an advanced technology, LSS, if implemented successfully, can help increase productivity, significantly reduce waste and defects of glass packaging production line, and thus increase company profits.

### 3.2 Significance of glass packaging

Compared to substitute packaging product categories such as aluminum cans, plastic bottles, or carton packaging, glass packaging has various significant advantages (Pattaphong, 2014). Glass packaging can enhance the image of product as more premium material. Also, the glass material is lead-free and non-toxic, and has good barrier properties. It can well prevent the oxidative erosion of various gases on the objects in the bottle, and can effectively prevent the volatile components of the contained objects from evaporating into the atmosphere; The glass bottle can be recycled and used repeatedly to reduce the packaging cost; the transparent glass can easily display the color of the contents of the bottle; The glass bottle is safe and hygienic, non-toxic and harmless, has good corrosion resistance and acid corrosion resistance, has special packaging advantages for the wine industry, dairy industry, edible oil industry, beverage industry, etc., especially suitable for acidic substances, such as vegetable beverages and edible vinegar packaging. In addition, because the glass bottles are suitable for mass production of the company's automatic production line, it has very large production advantages in the domestic and foreign markets.

#### 4. DMAIC Methodology of LSS in Manufacturing Company

Literature search is conducted by using "Implementing LSS in Manufacturing company" as a key word. Found that most of the literatures searched were implemented in manufacturing companies in India, and a few were implemented in European countries and China. There are few cases that LSS is implemented in manufacturing companies in Thailand or Southeast Asia.

Gu Yali (2017) introduced the case of N company implementing LSS by using DMAIC methodology to minimize costs. Company N is China's first automobile aluminum sheet production base, which achieves the recycling of high-end aluminum alloy materials and other high-end aluminum materials for automotive bodies. As a production company that uses recycled high-end aluminum materials as production materials, it pays special attention to utilize resources in the whole production process, reduce the production cost of enterprises, and obtain the competitive advantages of enterprises. They have optimized the cost of CASH products. In define phase, according to the established cost optimization goals, build LSS team. In measure phase, through the analysis of the manufacturing process, find the weak links and reveal the potential causes of process output defects or problems. In analysis phase, under the premise of having the advantages of new technology, the team has identified the main improvement measures and identified two auxiliary improvement measures which are Kanban and Total Production Maintenance (TPM). In improve phase, through the analysis of the production cost of CASH products from raw materials to production and transportation, the production process was improved, the production cost of products was redistributed, and the production cost of CASH products was reduced. Through implementing LSS, Company N successfully reduced the production cost of CASH product by 9.58%.

In India, Vinodh, *et al.* (2014) conduct a case study of company T which is a company that is engaged in the production of liquid TVs, and the production still uses traditional methods. The company found that the cost of production was very high, especially the labor cost, which led to a decline in profits, so the company decided to implement LSS to integrated production to reduce production waste and manpower waste. In the definition phase, the waste of processes and personnel, and the waste generated in the packaging phase were found. In the measure phase, they collect waste data on the factory production line. In the analysis phase, they conducted eight waste analysis, and indirect personnel work saturation analysis. In the improvement stage, improvements were made to known sources of waste. In the control stage, they standardized the production and operation process, the operator and the operation time, use the standardization to control the entire production process, and then train the operator to stabilize the results achieved.

## 5. DMAIC Methodology of LSS in Manufacturing Company Glass Packaging

### 5.1 LSS Define phase

#### 5.1.1 Manufacturing process of glass packaging

The manufacture process of glass packaging is straightforward shown by using flowchart and explain following.

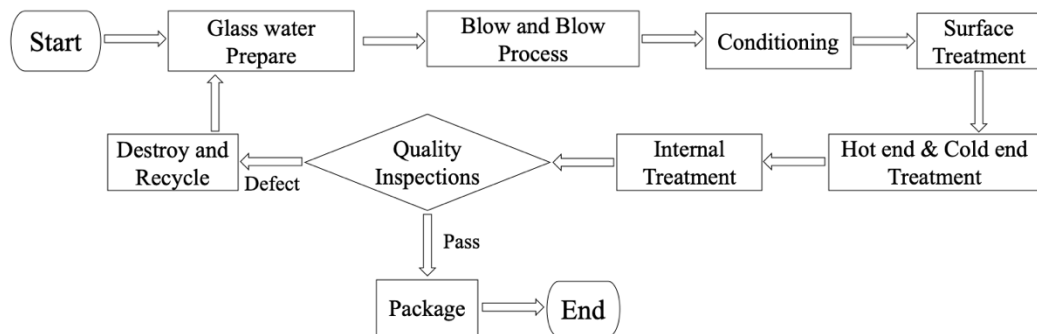


Figure 3 Flowchart of glass packaging manufacture process

Source: <http://www.dfrefra.com>

To product a glass bottles need more than ten kinds of raw materials. The processed raw materials are mixed evenly according to a certain proportion, and put into the kiln using the feeder. The raw material is gradually melted into a nearly water-like liquid in the kiln. The clarified glass water gradually flows to the material channel. Next are six main steps to manufacture a glass packaging.

First step: Blow and Blow Process (Figure 4). Through this process, the glass packaging is basically formed.

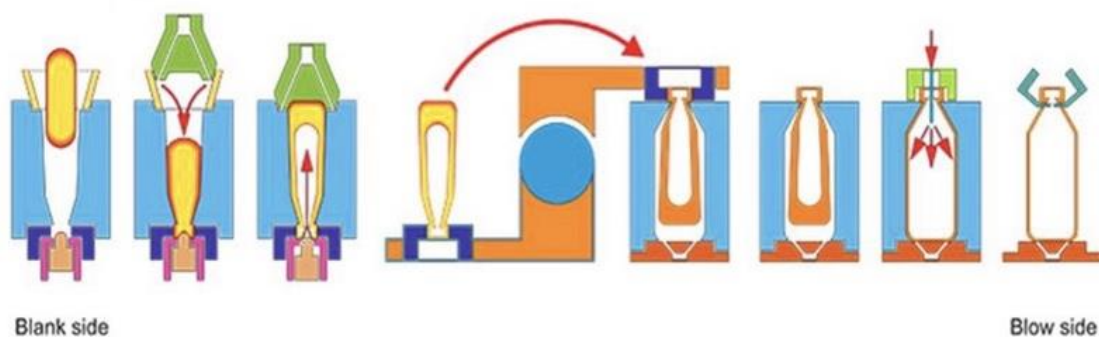


Figure 4 Blow and Blow Process

Source: <http://www.dfrefra.com>

Second step: Conditioning. After the blown glass container is formed, it is placed in an annealing furnace, the temperature is lowered to below 900°F, then reheated, and then slowly cooled to eliminate the pressure in the container.

Third step: Surface Treatment. Carry out external treatment to prevent abrasion which making the glass easier to break. The coating is sprayed on the glass surface and reacts on the glass surface to form a tin oxide coating.

Fourth step: Hot end treatment by using tin oxide coating.

Fifth step: Internal Treatment. Makes soda lime glass into treated soda lime glass.

Sixth step: Quality Inspections. Measure the weight of the bottle and checking the size of the bottle. After leaving the cold end of the furnace, the bottle will pass through an electronic inspection machine that automatically detects failures. After passing through the electronic inspection machine and arriving at the packaging room, staff will remove the defective products and carry out destruction. The raw materials will be recycled. The qualified products are packaged in different ways, they will be transferred to the warehouse with forklifts and prepare for loading.

#### 5.1.2 Problem definition.

Based on customer feedback and production practices, experts in the BJC's glass packaging division identified quality defects in glass packaging. Bursting of the neck and mouth of glass bottles is a common quality defect in the production process of glass bottles, and it is also one of the important factors that cause leakage after pressing the glass bottle cap. In the production of glass bottles, the bottle mouth burst phenomenon occurs almost every day. Since it occurs at the very beginning of the manufacturing process, once it occurs, the subsequent production process will be meaningless. Once the problem is improved, defects will be greatly reduced and the productivity of the production process will be improved.

#### 5.2 LSS Measure phase

The essence of LSS is to eliminate waste in the manufacturing process. In manufacturing organizations, there are generally seven types of waste. Waste is classified by its impact on product manufacturing.

Type of waste	Effect
Over production	Over inventory Increase warehousing costs Economic losses
Over inventory	Excessive use of warehouse Increased warehousing costs



Unnecessary transportation	Logistics loss
Defect and rework	Increase production costs Waste time
Over processing	Excessive use of machines Increase maintenance costs
Unnecessary motion	Waste time Effort loss
Waste waiting time	Long production time Increase costs of production

Table 2 Waste categorization

Source: <https://kanbanize.com>

The quality defects of bottle mouth and bottle neck bursting will cause waste of rework, result in production cost increase and waste of time.

### 5.3 LSS Analysis phase

Cause-and-effect diagram is used to define the actual source of these defect.

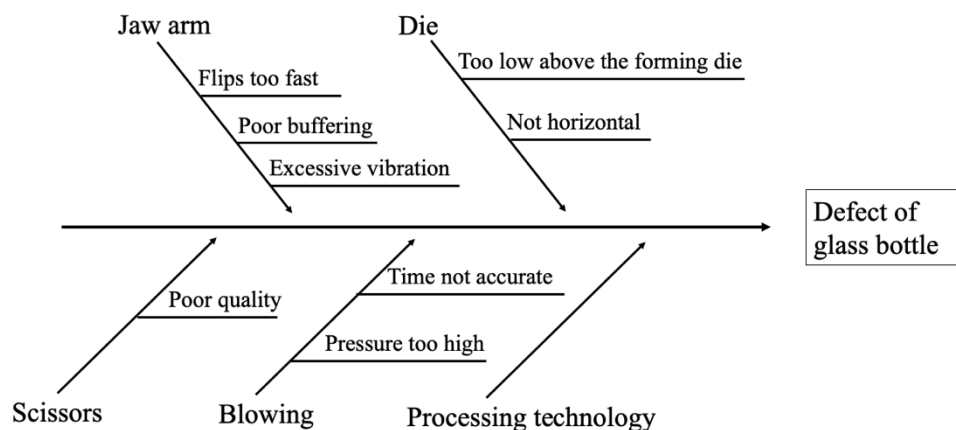


Figure 5 Cause-and-effect diagram

Source: <https://m.sohu.com>

There are reasons for the bottle mouth burst. Firstly, the jaw arm is turned too fast, the jaw arm is not well cushioned, and the vibration is too large. Secondly, the die is too low above the mold, or not horizontal. Thirdly, the quality of scissors the used to cut glass water is poor. Fourthly, the time of blowing is not accurate enough, the blowing pressure is too large, and the inner blowing tube is too short or too thick. Finally, the processing technology is lacking

#### 5.4 LSS Improve phase

Possible causes are indicated in the cause and effect diagram (Figure 5). Verify each possible cause and the results are listed in Table 3.

Cause	Cause validation	Expert's opinion
Flips too fast	The jaw arm turns too fast	Significant
Poor buffering and Excessive vibration	The jaw arm is not well cushioned and the vibration is too large	Significant
Too low above the forming die	The die hits the mold	Significant
Not horizontal	The die opening is too violent	Insignificant
Poor quality of scissors	Poor shear quality of glass water	Significant
Blowing time not accurate	Blowing time is too long or too short	Significant
Blowing pressure too high	Blowing pressure is too high	Insignificant

Table 3 Cause validation

Source: <https://m.sohu.com>

For causes that experts consider significant, improvement methods are proposed.

1. Check the length of the positive blowing tube, generally it is in same level with the bottom of the blowing head, or slightly longer than the blowing head, about 1-2mm is appropriate.

2. The depth of the blowing head should be slightly higher than the height of the die, and the coordination should be appropriate, otherwise it will crush the bottle mouth.

3. Debug the bottle-making control system, adjust the forming turnover speed and the opening of the die, and adjust the level of the die. Correct the working height of the die, the correct height is suitable for 1-2mm.

4. The length of time when the jam arm flips must not be too short. Too short will increase the flipping force and make the action too sharp. The flip angle should be around 50 degrees.

5. Keep the cutting quality of the scissors excellent during production, keep the scissors clean, and replace or clean the scissors regularly.

6. Under the premise of ensuring the inner diameter of the bottle mouth and satisfying the full shape of the bottle mouth, the blowing time should be shortened as much as possible.

### 5.5 LSS Control phase

At this phase, the organization establish operational regulation, use control charts, poka-yoke, Kanban, Sort, Set In order, Shine, Standardize and Sustain (5S) to do process control. Summarize the results of the implementation of LSS and find out new problem.

Tools	Implementation Target
Control Chart	Determine whether the quality is in a stable state
Poka-yoke	Find and correct errors immediately to prevent errors become defects
Kanban	Communicate information and unify understanding
5S	Improve production efficiency, reduce failures, and ensure quality

Table 4 Control Plan

Source: <https://wiki.mbalib.com>

After the above DMAIC phases, a complete LSS program has been implemented and the results of LSS will be shown and analyzed in the next section.

## 6. Key Ratios Analysis

As the definition of LSS states, this approach can improve processes, thereby improving customer satisfaction and organizational performance. The organizational performance can be measured by the financial aspects, such as revenue, net profits, ROA and etc.

An LSS deployment will usually reach breakeven within 6 to 12 months, and return in excess from \$50,000 to \$175,000 per project, (Harry, 1998). Academia believes that if properly implemented LSS, it can reduce the cost of poor flow by 75% to 90%. Large companies return 1-2% of sales each year, small and medium companies return 3-4% of sales each year will be considered to deploy LSS effectively. (Snee, 2004).

After the implementation of LSS in the BJC's glass packaging division, as shown in the Figure 3 below, the annual output of glass packaging increased by 12%. The profitability change brought by the increase in production will be analyzed following.

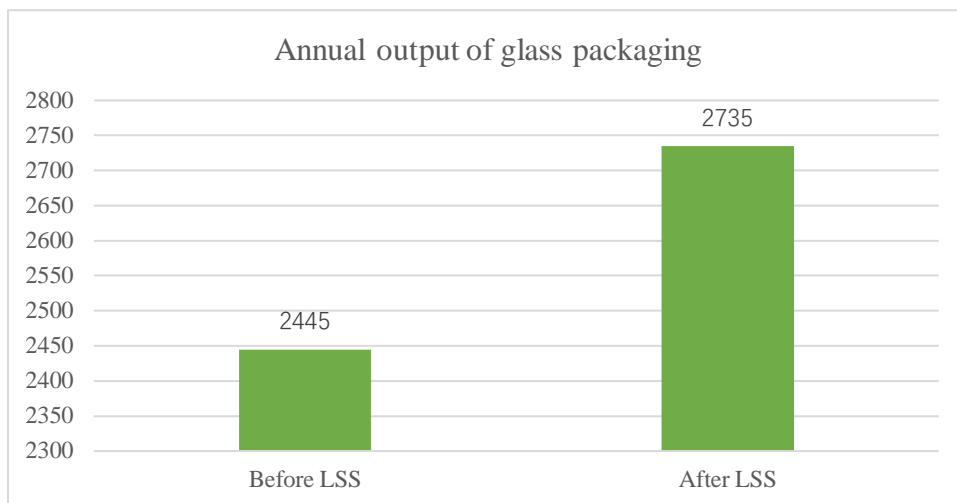


Figure 6 Increase in production output after LSS

Source: Annual Report of BJC Group

The key ratios of profitability including operating profit ratio, RPCE and ROA will be analyzed. Before this, line chart will be used to display and analyze the necessary data including sales, expense, profit before tax, net profit and total assets of BJC's glass packaging division from 2006 to 2019.

### 6.1 Sales (million baht)

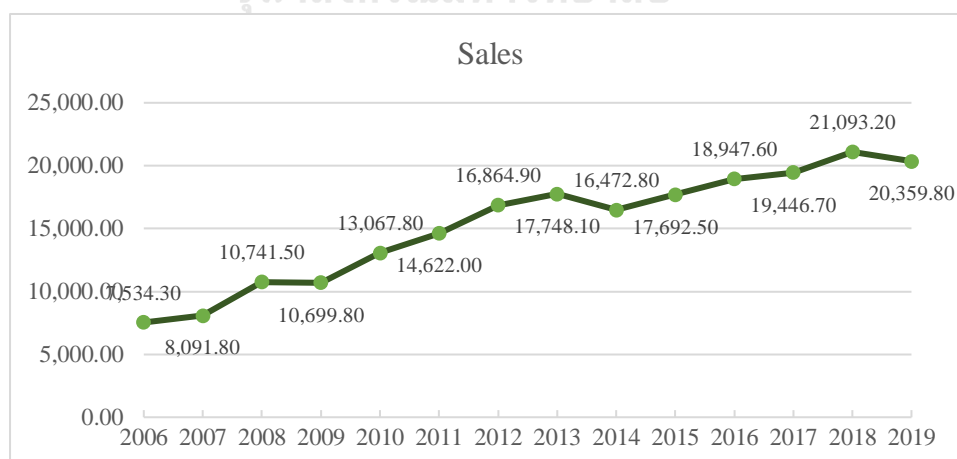


Figure 7 Sale of BJC's glass packaging division from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

As can be seen from Figure 6, from 2006 to 2019, the overall sales of glass packaging showed an upward trend, with an average annual increase of 8.41%. However, sales declined in 2009, 2014 and 2019. The largest declines occurred in 2014 and 2019, the declines were 7.19% and 3.48%, respectively. In addition to the sales growth of up to 32.75% in 2008, but it declined slightly in 2009, from 2010 to 2012, these three years was a period of sustained rapid growth of sales, which increased by 22.13%, 11.89% and 15.34% respectively.

## 6.2 Expense (million baht)

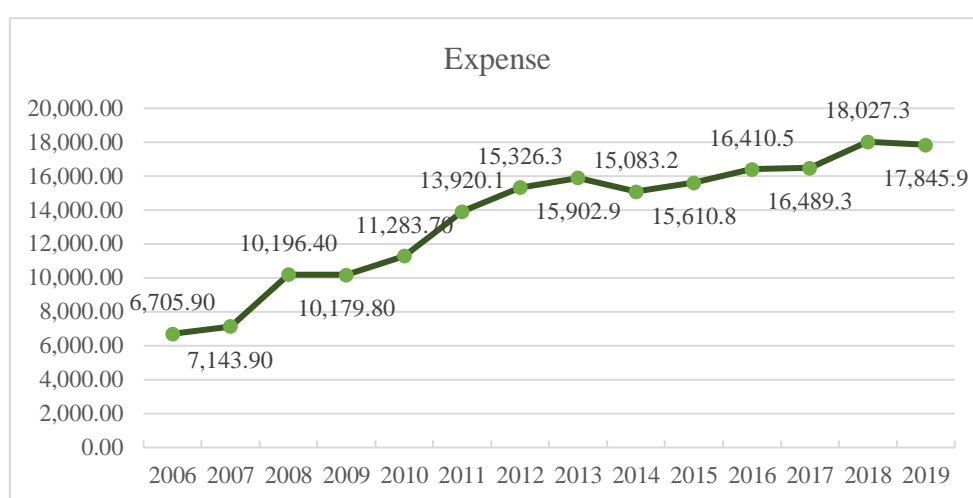


Figure 8 Expense of BJC's glass packaging division from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

Comparing Figure 7 and Figure 6 it is not difficult to find that the overall change trend of expenses is similar to sales. From 2006 to 2019, the overall expenses of glass packaging division showed an upward trend, with an average annual increase of 8.42%. Expenses declined in 2009, 2014 and 2019. The largest declines were in 2014 and 2019, which were 5.15% and 1.01%, respectively. In addition to up to 42.73% increase in expenses in 2008, from 2010 to 2012, these three years was a period of continuous and rapid increase in expenses, which increased by 10.84%, 23.36% and 10.1% respectively.

### 6.3 Profit before tax and Net profit (million baht)

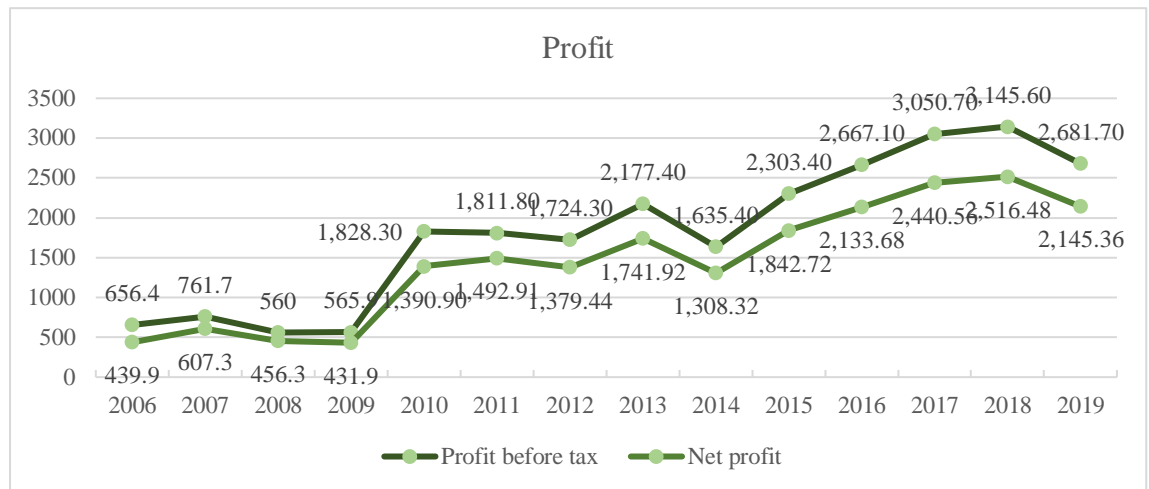


Figure 9 Profit before tax and net profit of BJC's glass packaging division from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

Profit before tax and net profit showed almost the same change trend. Although the profit of some years declines during the period, the overall profit from 2006 to 2019 showed an upward trend, with an average annual increase of 21.5%. Profits continued to decline in 2008 and 2009, and the decline in 2008 was as high as 25.67%. In 2010, the profit reached a rapid growth of 222.56%, but it failed to maintain. In the following two years, the profit declined slightly. In 2013, profits increased by 26.28% but decreased by 24.89% in the following year. From 2015 to 2018, profits continued to increase during these four years, of which the most rapid growth was from 2015 to 2017, with increases of 40.85%, 15.79% and 14.38% respectively. But in 2019, profits fell again by 14.75%.

Comparing Figure 7 and Figure 8 can find that the profit increased by 222.56% with the expense increased only 10.84% in 2010.

#### 6.4 Total assets (million baht)

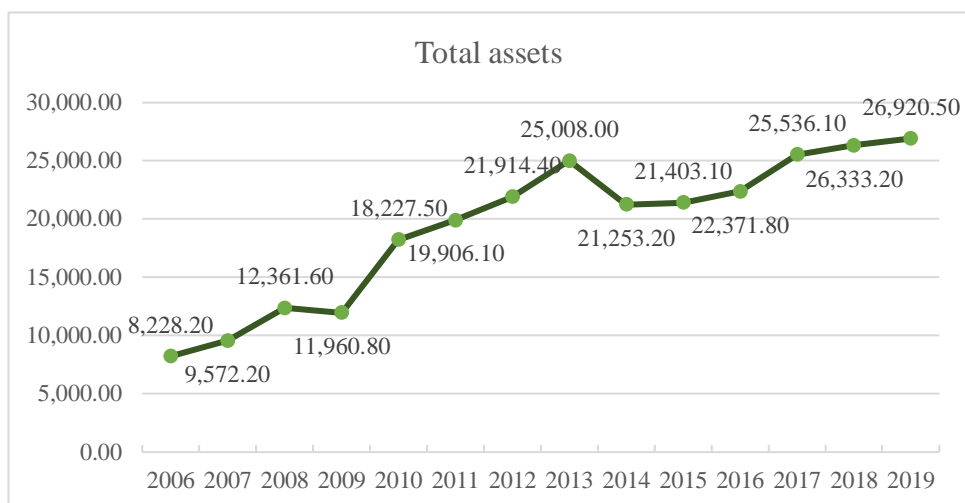


Figure 10 Total assets of BJC's glass packaging division from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

From 2006 to 2019, total assets showed an overall upward trend, with an average annual increase of 10.6%. Except for a slight decline in 2009 and a 15.01% decline in 2014, all other years have risen. From 2010 to 2013 continued to rise, of which total assets rose by as much as 52.39% in 2010. After the decline in 2014, there was another five-year increase from 2015 to 2019.

#### 6.5 Operating profit ratio

$$\text{Operating profit ratio} = \frac{\text{Operating income}}{\text{total revenue}} \times 100\%$$

Operating profit ratio of BJC's glass packaging division from 2006 to 2019 is calculated and displayed in Figure 10.



Figure 11 Operating profit ratio from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

The average operating profit ratio from 2006 to 2019 was 11.31%. The operating profit ratio was the lowest at 5.21% in 2008, and the highest was 15.69% in 2017. The operating profit ratio fell by as much as 44.62% in 2008, and then increased slightly in 2009. In 2010, the growth was as high as 164.53%, but the growth could not be sustained. In the following two years, the operating profit ratio fell continuously by 11.44% and 17.49%. It increased by 19.99% in 2013 but declined by 19.08% the following year. After three years of continuous rapid growth from 2015 to 2017, it fell by 4.94% and 11.68% in 2018 and 2019, respectively.

BJC's glass packaging division began to implement LSS in 2010, and its operating profit ratio increased by 164.53% in 2010, which shows that implementing LSS has greatly helped the company increase the operating profit provided by product sales in the first year. However, the operating profit ratio fell for two consecutive years, which shows that the company lacks late control of LSS and lacks sustainability.

## 6.6 RPCE

$$RPCE = \frac{\text{total profit}}{\text{total cost}} \times 100\%$$

RPCE of BJC's glass packaging division from 2006 to 2019 is calculated and displayed in Figure 11.



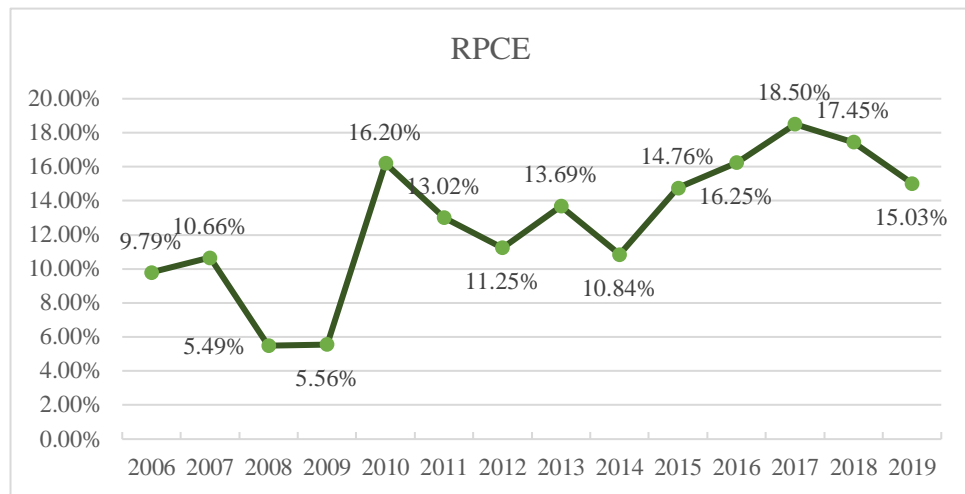


Figure 12 RPCE from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

The change trend of RPCE is similar to the operating profit ratio. The average RPCE from 2006 to 2019 was 12.75%. The lowest RPCE was 5.49% in 2008 and the highest was 18.5% in 2017. RPCE dropped by 48.49 % in 2008, and then increased slightly in 2009. The growth in 2010 was as high as 191.47%, but the growth cannot be sustained. In the following two years, RPCE dropped by 19.67% and 13.56% continuously. In 2013 it increased by 21.7%, but the following year it decreased by 20.81%. After three years of continuous rapid growth from 2015 to 2017, it fell by 5.69% and 13.88% in 2018 and 2019, respectively.

In 2010, when BJC's glass packaging division started implementing LSS, RPCE rose by a large amount of 191.47%, which shows that the implementation of LSS has a significant effect on controlling company costs and reducing production costs in the first year, but in the long run, the company lacks of the ability to maintain the role of LSS, which can be seen from the continuous decrease in RPCE in the following two years of 2010.

#### 6.7 Return on total assets ratio (ROA)

$$ROA = \frac{\text{net income}}{\text{total assets}} \times 100\%$$

Return on total assets of BJC's glass packaging division from 2006 to 2019 is calculated and displayed in Figure 12.

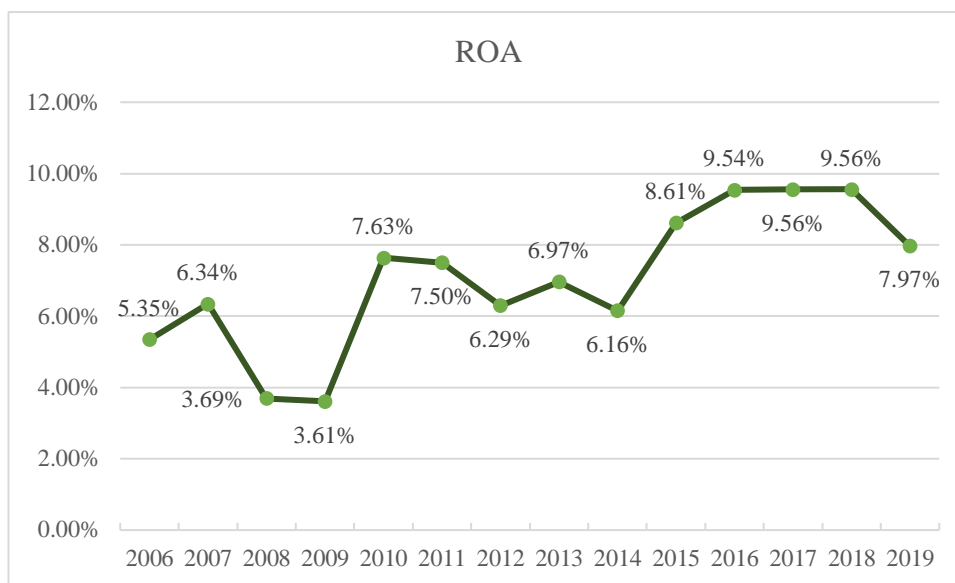


Figure 13 ROA from 2006 to 2019

Source: Financial Statements of BJC's glass packaging division from 2006 to 2019

ROA showed an overall slight upward trend, with an average ROA of 7.05%. The highest was 9.56% in 2017 and 2018, and the lowest was 3.61% in 2009. ROA continued decrease in 2008 and 2009, of which a decrease of 41.82% in 2008. But in 2010, it increased significantly by 111.32%. After a substantial increase, it was a two years decline. Although it increased by 10.66% in 2013, it fell by 11.62% the following year. ROA continued to grow from 2015 to 2017, and 2018 remained the same as 2017, after that it fell by 16.61% in 2019.

ROA increased by 111.32% in 2010, which shows that the implementation of LSS can greatly help the company to improve asset utilization efficiency in the first year. Similarly, due to the company's lack of late control of LSS and lack of sustainability, ROA continued to decline in 2011 and 2012

Through the above analysis of key ratios, the following summary can be made. In the first year, the implementation of LSS by BJC's glass packaging division has been very successful because it has greatly improved various profitability ratios. In the long run, the effects of LSS have not lasted too long because the ratios have continued to decline in the following two years after 2010. Of course, such changes cannot ignore the factors of change of economic environment, changes in market demand and energy prices, but can be seen from the figures, the change before and after 2010 is normally not more than 20%, but in 2010, it increased more than 100%, so it can be seen as the impact of LSS. Overall, BJC's glass packaging division lacks control and maintenance of LSS results, and the implementation of LSS lacks sustainability.

## 7. CSFs of Implementing LSS in BJC's Glass Packaging Division

CSFs are those factors that are critical to the success of any organization, in the sense that if the objectives associated with the factors are not achieved, the organization will fail. (Rockart, 1979) This section will combine literature review with the actual situation of BJC's glass packaging division to explore the CSFs of BJC's glass packaging division implement LSS.

I use "CSFs for implementing LSS " and "Barriers and challenges in implementing LSS " as keywords to conduct a literature search, the CSFs form literature review are summarized as follow:

Author(s)	Year	CSFs
Wang Ping	2017	(1) Focus on system operation
		(2) Establish a reward and recognition system
		(3) Focus on practical results
		(4) Get the support of top management
		(5) Use management methods and tools scientifically
		(6) Enterprise beliefs and culture
Antony, J., Hilton, R. J., & Sohal, A.	2012	(1) Competence of the project leaders
		(2) Competence of the deployment facilitator
		(3) Competence of the organization
Spanyi and Wurtzel	2003	(1) Visible management commitment
		(2) Shared understanding of core business processes and their critical characteristics
		(3) Rewarding and recognizing the team members
		(4) Communicating the success and failure stories
Achang a, P., Shehab, E., Roy, R. and Nelder, G.	2006	(1) Leadership and management
		(2) Finance
		(3) Skills and expertise
		(4) Culture of the recipient organization
Jeyaraman, K., & Teo, L. K.	2010	(1) Management engagement and commitment
		(2) Reward and recognition system
		(3) Organizational belief and culture
		(4) Frequent communication and assessment on LSS results
		(5) Project prioritization, selection, reviews and

		tracking
--	--	----------

Table 5 Summary of CSFs

Source: Wang Ping (2017), Antony et al. (2012), Spanyi et al. (2003), Achanga et al. (2006), Jeyaraman et al. (2010)

When any advanced method is promoted, there will be various barriers and challenges, the implementation of LSS is no exception.

Binqing *et al.* (2015) conducted a survey and found that 50% of enterprises have not achieved significant results after implementing LSS. This has greatly dampened the enthusiasm for investing in and implementing LSS program. There are many analytical literatures point out the failure of implementation of LSS, which can be roughly divided into the following aspects: insufficient support from senior management; lack of incentive mechanisms, the departments do not cooperate with each other; the project report showed significant cost savings and a high rate of return, but no significant improvement was shown in the financial statements. In order to prevent the implementation of LSS falling into a vicious circle, and to avoid the illusion that the implementation of LSS is useless after managers and employees have worked on a number of projects, it is necessary to conduct an overall benefit analysis of the improvement results of each project and reflect it in the company's financial statements. It has the effect of tracking the long-term benefits of the project's results, thereby reducing the risk of the company's failure to implement LSS. The authors also pointed out that in the implementation of the LSS program, the improvement of efficiency and quality is only a by-product, and the financial benefit is the main output of LSS.

Yadav *et al.* (2018) identify and prioritize 27 LSS barriers and 22 solution approaches to facilitate LSS implementation through literature reviews and using feedback from industry experts. Authors divided barriers into five categories:

(1) Managerial barriers including weak adjustment of management strategy; Continuous improvement of misalignment between project and organizational goals; Poor utilization of resources (finance, organization, technology, etc.); Ineffective performance evaluation system; Lack of attitude, commitment and participation of top management; Poor project cost estimates; Unclear organizational vision and future plans.

(2) Informational barriers including poor communication within the department; Lack of training and education; Inefficient LSS tool selection; Inefficient quality information and analysis; Insufficient technical resources.

(3) Human resource barriers including resistance to cultural change; Weak employee participation in the project; Poor LSS linked to the reward system; Lack of experienced LSS executives.

(4) Organizational barriers including insufficient organizational resources to effectively execute LSS program; Poor infrastructure; Poor organizational capabilities;

Copy LSS strategies from other organizations; Poor candidates for Belts training; The link between program goals, organizational goals and customer needs is incorrect.

(5) Independent barriers including insufficient understanding of different types of customers; Inappropriate project management; LSS cannot be implemented smoothly without effective models or guidelines; Insufficient connection with vendors.

Authors point out that rigid management policies and narrow mindsets are the main barriers to the effective implementation of LSS. In the solution approach, "management commitment with LSS " is at the top.

BJC's glass packaging division is committed to improving safety, quality, productivity, supply chain and personnel development. They believe that the integration of Lean Production and Six Sigma will lead to sustainable positive development and continuous change. Unfortunately, from the previous section, it can be found that the main problem of the LSS implemented in the BJC's glass packaging division is lack of sustainability. Combined with the CSFs summarized from the literature review, the CSFs of implementing LSS in BJC's glass packaging division are as follow:

(1) Long-term engagement and commitment of management: As a large-scale group with many businesses units, BJC Group has a corresponding executive vice president in each business units. Without the continuous support and commitment from top management, the true importance of the initiative will be in doubt and the energy behind it will be weakened (Pande et al., 2000). As the top management of the packaging supply chain, the executive vice president should become the advocate and organizer of the LSS program, play an active role in the practice of the LSS, make LSS to be a method that enhance the appeal and cohesion of the enterprise, and become the main driving force for the continuous promotion of the LSS program. Management should fully communicate and coordinate with the employees involved, and integrate LSS into the organizational culture. It can help to advance LSS in a short time, and to make LSS better integrated with the actual situation of the enterprise.

(2) Rigorous project supervision and detailed project report. From the financial statements, we can find the huge return of LSS in 2010. The profitability of that year has increased by nearly 200% compared with the previous year, but there has been a continuous decline of more than 10% in the following two years. This makes one wonder whether the project report has exaggerated benefits. Therefore, strict supervision and evaluation of project returns is necessary. This supervision is not limited to the management, but also the financial department. The financial department should establish a perfect financial index system and financial benefit calculation criteria, and strictly review and evaluate the project returns.

(3) Based on the actual situation of the business itself. Simple imitation, and copying other's experience is not in line with the actual situation of the business. The effect of the LSS program reflected in the financial statements is short-lived. The reason is likely that BJC's glass packaging division did not adjust the LSS framework in time according to the actual situation of the company's development. LSS framework is not fixed, it needs to be adjusted in time according to the company's strategy and the actual situation of the company's operations to achieve the best results.

Moreover, there are many CSFs to push the success of LSS implementation, and each critical success factor depends on each other to make the LSS procedure successful. Although some important CSFs require more concentration, minor CSFs must not be ignored (Leam, 2010).

## 8. Industry Trend

Snee (2009a, b) said that during financial crisis, leaders and managements view LSS as a way to reduce costs and maintain cash flow. The author believes that continuous improvement can be the "cash cow" that organizations hope to have in this difficult period. LSS is a method of continuous improvement. Several companies use continuous improvement as a tool to build leadership, such as General Electric, DuPont and American Standards. With the development of enterprises, the work of leaders is more of leading change. The LSS method provides concepts, methods, and tools for change and continuous improvement. This makes the work of leader much easier. The leader only needs to consider the experience and competence of Green Belts, Black Belts or Master Black Belts to improve management efficiency.

Some LSS experts pointed out that the impact of the era of big data is not only for the Internet and information industry, but also the impact on traditional manufacturing. How to extract value from big data is a problem that no organization can ignore (Siyu, 2016). The company's operations and the Internet are gradually converging, and the Internet is no longer a concept. How should we analyze the large amounts of data in the Internet and how to extract useful information from these data? This is also a challenge to LSS. At present, the statistical analysis tools usually used in LSS can only perform some simple graphical analysis. Because these formats of data do not meet the requirements of LSS tools, it is difficult to conduct further analysis. In order to better extract the value of data in big data, a more reasonable sampling method needs to be set to make the data samples meet the analysis requirements. He also pointed out that the integration of LSS with the company's existing system is the best result of the LSS program, making LSS the DNA of the company and bringing tremendous development to the company.

Informatization and intelligence are inevitable trends in the future development of manufacturing industry. Informatization and intelligence will surely automate the process. People's participation in the manufacturing process will be less and less, and the impact of labor on product manufacturing will also be smaller and smaller. The machine will control production. Therefore, quality management will be more concentrated in process management, because the company is interested in the benefits brought by the output of production, and the quality of the production process directly affects the output of production. Measurement, analysis and improvement of the production process become particularly important. Talking about the measurement, analysis and modification process, so far, there is no more effective method than LSS, so in the future, the application space of LSS will be larger and larger, and it will be more and more give full play to its unique advantages (Boge, 2018).

## 9. Conclusion

BJC's glass packaging division it is one of the largest glass manufacturer in Southeast Asia, it produce various high quality glass packing. Before 2016, the packaging supply chain has been the main source of revenue for the group. In 2016, BJC Group acquired Big C. Since then, the packaging supply chain become the group's second largest source of revenue.

Due to the increasingly fierce market competition, enterprises in the manufacturing industry are looking for ways to improve production and management processes to maintain market competitiveness. It requires manufacturing enterprises to continuously improve productivity, reduce production costs, and continuously improve product quality. BJC's glass packaging division has been working hard to increase efficiency and productivity to reduce production costs and improve the quality of products through various standardized systems, including LSS. LSS is a combination of Lean Production and Six Sigma management, essence is to eliminate waste. It is considered to be an advanced method to reduce product costs and improve product quality.

BJC's glass packaging division started implementing LSS in 2010. In define phase, through the analysis of manufacturing process of glass packing by using flowchart, based on customer feedback and production practices, experts in the BJC's glass packaging division identified quality defects in glass packaging which is bursting of the neck and mouth of glass bottles always occurred in the blow and blow process, will cause leakage after pressing the glass bottle cap. In measure phase, seven types of waste are classified by its impact on product manufacturing, and confirmed that the quality defects of bottle mouth and bottle neck bursting will cause waste of rework, result in production cost increase and waste of time. In analysis phase, cause-and-effect diagram is used to define the actual source of these defect. Indicated

that jaw arm, die, scissors, blowing machine and processing technology are five sources of these defect. In improve phase, the significance of each possible cause is verified, and suggestions for improvement for each significant cause is proposed. In control phase, various LSS tools are used to implement process control which are control charts, poka-yoke, Kanban and 5S. After the implementation of LSS in the BJC's glass packaging division, the annual output of glass packaging increased by 12%.

In order to assess the impact of the implementation of LSS on the company's profitability, this research is conducted. There are three objective of this research which are firstly, to assess the impact of the implementation of LSS on the company's profitability; secondly, to explore the CSFs for implementation of LSS in BJC context; lastly, to describe the industry trend of implementing LSS in the future.

To assess the impact, line chart is used to display and analyze the company's relevant data from 2006-2019. Operating profit ratio, RPCE and ROA are used as analysis indicators for profitability. Secondary data from annual report and financial statements from 2006 to 2019 that BJC published in website is used to calculate and analyze these indicators. Through the analysis of the profitability of the division before and after the implementation of LSS, the results show that operating profit ratio increased by 164.53%, RPCE increased by 191.47%, ROA increased by 111.32% in 2010, but all of them continued to decline in 2011 and 2012, which can be interpreted that the implementation of LSS by the BJC's glass packaging division has achieved huge returns in the first year, but due to the lack of sustainability, the long-term impact of the LSS program on the company is not sustained.

For this result, based on literatures review, this research summarizes the CSFs for implementing LSS and the barriers and challenges in implementing LSS. Then, combined with the actual situation of the division, three CSFs of the implementation of LSS in BJC context are proposed which are long-term involvement and commitment of management, rigorous project supervision and detailed project report, and based on the actual situation of the business itself to implement LSS.

At the end of this research, based on the viewpoint of the industry experts, the future trends of LSS in the manufacturing industry are described. During the financial crisis, leaders and managements viewed LSS as a way to reduce costs and maintain cash flow because LSS method provides concepts, methods, and tools for change and continuous improvement. This makes the leader's job easier. In additional, the era of big data is coming, it also has a great impact on traditional manufacturing, how to obtain value from big data is a major challenge to LSS in the future. At the same time, the unique advantages of LSS in informatization and intelligence will make LSS have more and more application space in the future.



## 10. Recommendation

Based on the above research and analysis of LSS, the recommendations for BJC's glass packaging division are proposed as follows.

Firstly, managers of packaging supply chain should continue to pay attention to the implementation process of LSS, especially in the late stage of the project, when the project has achieved initial results, it should not be taken lightly. Always maintain a high level of attention, highly engage, fully communicate and coordinate with the employees involved about organizational goals, leads by example and participation in LSS and provide the necessary support including but not limited to financial support, policy support.

Secondly, starting from the company's overall strategy, through a strategic map analysis, list many feasible projects, select the most beneficial to the company's profit goals for priority implementation, in addition to the benefit assessment conducted by the project team, the finance department is necessary to conduct an overall benefit assessment of the LSS program from a financial perspective to avoid double calculation of certain benefits in benefit evaluation of different projects. The finance department can formulate a benchmark and rules that all project teams follow to evaluate the correctness of the estimated financial benefits of each project.

Thirdly, the LSS project should continue to follow the company's strategy and operation. When the company's management makes strategic adjustments or changes in the direction of operations, it must timely evaluate new projects, grasp the main contradictions of the company's operation and management, identify weaknesses in production, adjust the LSS framework in time for the weak links in production management, and integrate the LSS into the actual management of the business to achieve the best improvement effect.

Lastly, applying LSS in the field of enterprise human resources management. Based on the data, the qualitative data of traditional human resource management is converted into the standardized quantitative data of LSS, and the human resource goals are objectively and standardizedly described, and the qualitative goals are converted into quantitative goals. Taking system analysis as the core, the simple analysis of the single factor of traditional human resource management is converted into the comprehensive analysis of LSS. Through the digitization of daily affairs, find deficiencies in work and improve it, which helps to improve the ability of the executive layer of the enterprise, and also helps the management to optimize the organization system and process, improve work efficiency and save management costs.

From another perspective, in recent years, the market's demand for glass packaging has been increasing, and the requirements for product quality have also been increasing. BJC's glass packaging division should pay more attention to the research and development of new products, and invent new production technologies,

make full use of the advantages of big data, obtain value from big data, increase the investment of technology, promote process automation. Release new products to the market, provide various products, develop and improve product performance to maximize product quality, to meet and exceed customers' expectations. In addition, adhering to the principle of sustainable development, research and development of more environmentally friendly glass formulations, recycling energy in the production process can effectively reduce production costs and improve market competitiveness, ultimately achieve the result of improving profitability.

On the other hand, due to the limited local market and production capacity in Thailand, BJC's glass packaging division can find new markets and customers from abroad through joint ventures with foreign companies to increase glass packaging sales and increase revenue. Coordinate production capacity with foreign joint ventures to improve the efficiency and competitiveness of domestic and foreign markets.

Through more reasonable implementation of LSS, BJC's glass packaging division can reduce product costs, improve product quality, maximize customer satisfaction and product reputation, thereby improving the company's competitive advantage, coupled with the development of new technologies and new products and joint ventures with foreign companies, BJC's glass packaging division is expected to have better development in the future.

---

## REFERENCES



จุฬาลงกรณ์มหาวิทยาลัย  
**CHULALONGKORN UNIVERSITY**

- 
- Antony, J., Hilton, R. J., & Sohal, A. (2012). A conceptual model for the successful deployment of LSS. *International Journal of Quality & Reliability Management*
- Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006), "CSFs for lean implementation within SMEs", *Journal of Manufacturing Technology Management*, Vol. 17 No. 4, pp. 460-71.
- Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K. (2016). The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, 139, 828-846.
- Gu Yali (2017). LSS Management Enterprise Cost Optimization Recommendations. *Accounting Monthly*, 33-37.
- Harry, M.J. (1998), "Six Sigma: a breakthrough strategy for profitability", *Quality Progress*, May, pp. 60-4.
- Jeyaraman, K., & Teo, L. K. (2010). A conceptual framework for CSFs of LSS. *International Journal of LSS*.
- Leam Kee Teo (2010). CSFs of LSS. *International Journal of LSS*. pp. 191-215.
- Mohamed K. Hassan, "Applying Lean Six Sigma for Waste Reduction in a Manufacturing Environment." *American Journal of Industrial Engineering* 1, no. 2 (2013): 28-35. doi: 10.12691/ajie-1-2-4.
- Rockart J (1979). Chief executives define their own data needs. *Harvard Bus Rev* 57(2): 238–241.
- Pande, P.S., Neuman, R.P. and Cavanagh, R.R. (2000), *The Six Sigma Way: How GE, Motorola and Other Top Companies are Honing Their Performance*, McGraw-Hill, New York, NY.
- Siyu. (2016), *When Six Sigma encounters big data*, 3-4.
- Snee, R.D. (2004a), "Can Six Sigma boost your company's growth?", *Harvard Management Update*, June, pp. 2-4.
- Snee, R.D. (2004b), "Six Sigma: the evolution of 100 years of business improvement methodology", *International Journal of Six Sigma and Competitive Advantage*, Vol. 1 No. 1, pp. 4-20.
- Snee, R. D. (2009). LSS—getting better all the time. *International Journal of LSS*.
- Spanyi, A. and Wurtzel, M. (2003), "Six Sigma for the rest of us", *Quality Digest*, available at: [www.qualitydigest.com/july03/articles/01\\_articles.html](http://www.qualitydigest.com/july03/articles/01_articles.html) (accessed February 26, 2005).
- Swarnakar, V., & Vinodh, S. (2016). Deploying Lean Six Sigma framework in an automotive component manufacturing organization. *International Journal of Lean Six Sigma*.
- Wang Ping. (2017), Ways and Methods of Implementing LSS Management, *Journal of Scientific Management*, 147-148.

Xiao Binqing & Liu Wenlong (2015), Research on LSS Model Renewal Based on Cost Control, *Journal of Scientific Decision*, 55-68.

Yanzhen Wu. (2010), The application of construction engineering economy in engineering management [J]. *Hua Zhang*, 2010 (10).

Yan Siyu. (2018), Modern Enterprise Quality Management Based on LSS Management. *Chinese Collective Economy*, 35-40.

Yadav, G., Seth, D., & Desai, T. N. (2018). Application of hybrid framework to facilitate LSS implementation: a manufacturing company case experience. *Production Planning & Control*, 29(3), 185-201.



---

## VITA

**NAME** Mengyuan Wu  
**DATE OF BIRTH** 24 November 1995  
**PLACE OF BIRTH** China



จุฬาลงกรณ์มหาวิทยาลัย  
CHULALONGKORN UNIVERSITY