



TAMPERE UNIVERSITY OF TECHNOLOGY

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**ALTERNATIVE SCENARIOS FOR ASSEMBLY  
MANUFACTURING: AUTOMATION AND OUTSOURCING IN THE  
GARMENT INDUSTRY**

Master of Science Thesis

Prof. Miia Martinsuo has been appointed as the examiner at the Council Meeting of the Faculty of Business and Technology Management on December 8, 2010.

# ABSTRACT

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The objective of this research was to investigate the assembly manufacturing strategy for the future European garment industry. Outsourcing and automation were the strategic selections to assembly manufacturing for alternative scenarios. An ultimate goal was to find out whether outsourcing could be replaced by automation as a manufacturing strategy of garment assembly in the future.

The research was carried out by literature reviews and scenario approach to examine the future of garment assembly. First, the two strategic alternatives: outsourcing and automation were reviewed in addition to the theory of manufacturing strategy. Besides, the driving forces and consequences were studied in respect of the two strategic alternatives. The contradictions between them were further analysed in accordance with the manufacturing objectives: cost, quality, delivery and flexibility in the garment industry aspect. Subsequently, the scenarios were developed based on the uncertainties derived from the similarity and relationship of the two strategic alternatives for assembly manufacturing.

The future scenarios of garment industry were then illustrated with the two uncertainties: availability of labour and technology. With different level of labour supply and technology, the four scenarios were generated with the GBN matrix technique. Four strategies: other options, outsourcing focus, automation focus and combination strategies were recommended for the scenarios. The final conclusion to the research question was that for garment manufacturing in the future, the combination of outsourcing and automation is a more viable strategy than completely substituting outsourcing by automation.

## PREFACE

This Master's thesis presents an analysis on the two strategic alternatives for manufacturing: outsourcing and automation, in respect to the European garment industry in the future. This is a self-enhanced studied, even though, the analysis could be important to the industry, as the analysis is based on the LEAPFROG project by European Union. The study is also carried out in scenario approach, with the development of future under two uncertainties: labour supply and technology, the four scenarios are generated. The scenarios are accompanied with recommendation for future plan. It has been an interesting and rewarding experience for me to investigate the future in a scenario approach. Despite the seminar paper is based on secondary resources, it is still an important learning process to track out the valuable information from all.

The thesis is finally completed with numerous hours spent on the study. Besides, I am very delighted to thank my supervisor Professor Miia Martinsuo for her guidance in supporting my study and valuable comments for my research. Lastly, I would like to thank the support and encouragement from my family and friends in motivating me to go through all the difficulties in this period.

Tampere, 19 September, 2011

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Chui Chi Yuen

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## ABBREVIATIONS AND NOTATION

CMT	Cut, Make and Trim
GBN	Global Business Network
ICT	Information and Communication Technology
JIT	Just-In-Time
LEAPFROG	Leadership for European Apparel Production From Research along Original Guidelines
LoA	Level of Automation
MORPHOL	A computer program that also manages the complexity of morphological analysis.
OEM	Original Equipment Manufacturer
OS/SE	Option Development and Option Evaluation
QR	Quick Response
WCM	World Class Manufacturing

# 1. INTRODUCTION

## 1.1. Background

Manufacturing is a traditional function in a company. Yet, it has been viewing strategically as a competitive weapon (Miller and Rogers, 1956). Manufacturing strategy can be defined as the pattern of manufacturing choices that a company makes (Hayes and Wheelwright, 1984). There are different strategies available for improving the manufacturing efficiency in order to achieve the manufacturing objective: cost, quality, delivery and flexibility (Skinner, 1969). Human labour is a major factor in manufacturing, but labor accounts for about two-thirds of the cost of making and selling products (Cooper, 2004). Labour cost is high especially in the developed countries, therefore certain strategies has been adopted to reduce the manufacturing labour cost.

In ancient manufacturing, industry used only manual labour and simple tools for production. It is time consuming and expensive with high labour cost. For instance, the history in different industries has shown to us that, when the manual process increases the cost of the production, machineries would be invented to replace the human work. This is the foundation of Automation and it is a modern concept to describe the replacement of human activity by machine activities (Satchell, 1998). Hence, Automation is a historical and naturally proceeded strategy. There are different innovation to automate the more complicated process, for example, computerize, mechanics and more recently the robotic engineering. As innovation has brought ever-cheaper computing power and new ways to make use of it, capital has become increasingly inexpensive relative to labor (Cooper, 2004). Anyhow, the ultimate aim is to improve the efficiency in manufacturing. Hence, implementing automation technologies for manufacturing is regarded as a manufacturing strategy.

In the near decades, globalization moved the production activity from developed to developing countries (Dicken, 2003). The original equipment manufacturer (OEM) companies have increasingly outsourced part or all of their manufacturing operations to third party manufacturers (Sousa and Voss, 2007). Focus on core competencies (Prahalad and Hamel, 1994) and accesses to low-cost labor (Farrell, 2004) are the major motives for offshore-outsourcing of manufacturing processes. In other words, outsourcing the manufacturing activities to third parties is one of the manufacturing strategies as well.



Within the manufacturing strategies aspect, outsourcing and automation help companies to improve manufacturing efficiency in respect of labour cost reduction. These two strategies are merely discussed together, but there is a relationship between them in the textile and clothing industry which was the very first traditional industry in the beginning era of manufacturing. In the past, the textile and clothing industry has already started the invention of spinning jenny and sewing machines in the industrial revolution (Ugo et al., 2011 ; Godley, 2001), which further developed to the state-of-the-art textile machinery in the present. It proved the long history of automation. Despite the development of modern machinery, garment assembly is still rather manual and labour intensive at the moment. The high labour cost of garment production especially in developed countries cannot be eliminated by automation, and thus offshore outsourcing production to low cost regions to reduce cost is a common practice in the clothing industry (Kumar and Arbi, 2008). Therefore, the garment assembly manufacturing could be trace back to the ultimate driving force of outsourcing, the major root cause, the difficulty in garment assembly automation. Hence, there is a need for a thorough discussion among these two manufacturing strategies.

## **1.2. European garment industry**

In Europe as well as around the world, least developed and developing countries have used production of textiles and apparel as a means of industrialization. During the last 50 years, developed countries maximized their international competitiveness related to production and have since seen their textile and apparel industries decline. (Kunz and Garner, 2007)

Garment industry is categorized in the fast moving industries (Christopher et al., 2004), the keen competition in the fashion industry is because of its fast changing trend. As mentioned earlier, many western fashion companies offshore outsourcing the manufacturing process to the low labour cost countries in Asia such as China and India, the long distance suppliers slow down the responsiveness in the supply chain. The long production lead time and slow responsiveness in addition to the traditional forecasting error is the biggest challenges for many companies in Europe. The challenge intensified by other problems arises from outsourcing such as hidden cost and flexibility (Christopher et al., 2004), which made outsourcing no longer a favourable strategy for manufacturing.

For instance, the root cause for outsourcing which is the difficulty in garment assembly automation is rarely discussed. Even though, garment assembly automation would be a potentially possible solution. It requires a highly reliable garment assembly system to replace the common but critical and labour intensive fabric handling tasks: ply separation and pick-and-place on pre-separated piles. (Saadat and Nan, 2002) The

difficulties in the development are that as textile fabric is flexible and delicate, a non-intrusive mechanical design to avoid damage to the fabric is essential. Also, precise positioning method is important for accurate assembly. Sensor for vision and detection are suggested to implement the match and place idea. Though certain research has pointed out the difficulty for automation, a study carried out by Leapfrog (2009) in Europe has focused on automated garment assembly. The overall objective is the complete automation of the garment assembling activities by means of innovative fast and highly re-configurable robotic devices.

The motivation of this study arises from the project Leapfrog (Leadership for European Apparel Production From Research along Original Guidelines), which is carried out from 2005 to 2009 under the European Union's Funding (app. 14 million Euro) and Euratex. The project proposes a revolutionary industrial paradigm based on research results in certain scientific-technological fields. One of the four research areas is Automated Garment Manufacturing. It investigates the innovation of intelligent robotics and fabrics joining techniques in automated sewing operations. It is not surprise that there are already existing technologies available for automation garment manufacturing. Yet, the transition from innovation to public adoption and mass production is still under investigation.

With the completion of this project, the results are published in the "Transforming Clothing Production into a Demand-Driven, Knowledge-Based, High-Tech Industry." It collects the short papers from the researchers involved in the Leapfrog project. This publication addresses different approaches to a drastic shortening of the whole cycle from conception to production and retail, as well as a shift from a labor intensive to a technology and knowledge intensive clothing manufacturing industry.

In fact, the objective of this project has an intention to move the outsourced garment assembly manufacturing process from Asia back to Europe. According to the Project Coordinator Walter et al. (2009), because of the major parts of handling and joining operations remain highly manual labour intensive, making the whole garment making process uncompetitive in high labour cost countries. Thus, the industry's response of a major shift of manufacturing to low labour cost countries often far away from the point of sale or consumption of the final product has in turn introduced additional complexities, risks and costs (Walter et al., 2009). For instance, by using the newly innovated technology, the automated garment assembly, this is going to help the entrepreneurs in the garment industry to restructure this handy process back to Europe.

### 1.3. Objectives

This study has a purpose to investigate the alternative strategies in manufacturing with respect to outsourcing and automation. With the focus in the garment assembly manufacturing, this paper look into the issues regarding the outsourcing and automation practices in the global fashion industry. Since outsourcing has been widely adopted in the industry, the major question would be whether the new innovation regarding automation could replace the outsourcing practice as a new manufacturing strategy in garment assembly or not, as Walter et al. (2009) proposed. The investigation of the alternatives development between garment assembly automation and outsourcing in different directions is needed.

Nonetheless, as automation technology for garment assembly is still under development stage, its impact is rather uncertain in the future. On the other hand, garment assembly outsourcing is widely practised in the industry, the existed problems are observable, yet the responses of the industrialist is still questionable. Hence, comparison of these two strategies under pile of uncertainties in the future would be difficult without any tools. Therefore, the scenario planning approach will be adopted in analysing and planning the future of garment assembly manufacturing. The major research question is:

- *“Can the new innovation regarding automation replace the outsourcing practice as a new manufacturing strategy in garment assembly?”*

In associate with the investigation, sub-questions are also pointed out:

- *How will garment assembly manufacturing for fashion industry look like in the future? What are the different future scenarios for garment manufacturing?*
- *How a company should react in each situation? What strategies should a company adopted in each scenario?*

Accordingly, the paper is first method with the literature reviews and it is divided into two parts. The first part of the literature reviews focus on the alternatives strategies regarding this research. It first interprets what are manufacturing strategies in general and then discusses the different strategies in manufacturing nowadays. Afterwards, the concepts of the two major strategies: outsourcing and automation in the paper is reviewed. The second part of literature reviews has the focus in the garment manufacturing industry. It first describes the global fashion industry and the trends in general. Then the discussion continues to analysis the challenges of outsourcing and automation in the garment assembly and manufacturing process. The final part of the research creates different scenarios regarding the future of garment assembly in the global fashion industry. These scenarios base on the uncertainty of the selection

between outsourcing and automation in garment manufacturing. It is then follow by the analysis of the four scenarios and recommendations for them.

The scope of this study is the focus on the content of manufacturing strategy but not the process. The investigation of the manufacturing strategy is focus on outsourcing and automation, excluding the other strategies. The consideration of garment manufacturing assembly is center to the sales in European market but not globally. The attention to the garment industry is pay on the assembly process in the manufacturing activity, which is the sewing process. As this study trying to foresight the garment assembly manufacturing in the future, regarding the technology of automation is not mature enough at the moment, thus the generation of the future scenario has the time frame approximately from 10 to 20 years later in 2021 to 2030.

## **2. METHODOLOGY**

### **2.1. Research approach**

This study is carried out in a qualitative research approach. The purpose of qualitative research is to gain understanding and insights; it is particularly relevant when prior insights about the phenomenon under scrutiny are modest, implying that qualitative research tends to be exploratory and flexible because of unstructured problems. (Ghuri and Grønhaug, 2010) This method reflects different perspectives on knowledge and research objectives. It is a mixture of rational, explorative and intuitive, the skills and experiences of the researcher play an important role in the analysis of data.

The data collection process is based on secondary resources. Secondary data are useful in finding information and in better understanding and explaining the research problem. It mostly starts with a literature review includes earlier studies on and around the topic of research. The major resources are from published books, journal articles, online data sources such as websites of firms, governments and other organizations. (Ghuri and Grønhaug, 2010) A systematic approach to search from different databases and journals are adopted.

### **2.2. Research framework**

#### **2.2.1. Formulation of strategy under uncertainty**

Regarding the research by Courtney et al. (1997), they pointed out several important ideas when formulating strategy under uncertainty, the three frameworks: level of uncertainties, postures and moves are explained in the following. Beforehand, they pointed out that even the most uncertain business environments contain a lot of strategically relevant information. First, it is often possible to identify clear trends. Second, there is usually a host of factors that are currently unknown but that are in fact knowable that could be known if the right analysis were done, i.e. the performance attributes for current technologies, are often unknown, but not entirely unknowable. Finally, the residual uncertainty remains after the best possible analysis has been done, for example, the performance attributes of a technology still in development. They also found that the residual uncertainty facing most strategic-decision makers falls into one of four broad levels which are so called the *Level of Uncertainties* as follow:

- *Level 1: A Clear-Enough Future.* A single forecast of the future that is precise enough for strategy development can be developed.
- *Level 2: Alternate Futures.* The future can be described as one of a few alternate outcomes, or discrete scenarios.
- *Level 3: A Range of Futures.* A range of potential futures can be identified. That range is defined by a limited number of key variables, but the actual outcome may lie anywhere along a continuum bounded by that range. There are no natural discrete scenarios.
- *Level 4: True Ambiguity.* Multiple dimensions of uncertainty interact to create an environment that is virtually impossible to predict.

After the relevant level of uncertainties is identified, a company can assume three strategic postures concerning uncertainty, and three types of actions can be used to implement that strategy. Postures defined as the intent of a strategy relative to the current and future state of an industry. The three strategic postures are defined as follow:

- *Shape the future:* Play a leadership role in establishing how the industry operates, for example: setting standards and creating demand.
- *Adapt to the future:* Win through speed, agility, and flexibility in recognizing and capturing opportunities in existing markets.
- *Reserve the right to play:* Invest sufficiently to stay in the game but avoid premature commitments.

Courtney et al. (1997) further emphasized that a posture is not a complete strategy. It clarifies strategic intent but not the actions required to fulfill that intent. Hence, three types of moves are especially relevant to implementing strategy under conditions of uncertainty which regarded as a portfolio of action:

- *No-regret move:* Strategic decisions that have positive payoffs in any scenario
- *Options:* Decisions that yield a significant positive payoff in some outcomes and a (small) negative effect in others
- *Big bets:* Focused strategies with positive payoffs in one or more scenarios but a negative effect in others

Following the structures of this formulation, identify the level of uncertainties and then spot out the postures and move, this research is carried out accordingly.

## **2.2.2. Adopting the scenarios planning techniques**

### *The concept of Scenarios planning*

In order to perform more comprehensive analyses appropriate to high levels of uncertainty, it is recommended to supplement with some standard strategy tool kit. Scenario-planning techniques are fundamental to determining strategy under conditions of uncertainty. (Courtney et al., 1997) Since the early 1970s, scenario planning has been a valuable strategic planning tool for companies that face uncertain futures (Wack, 1985; Schwartz, 1991; Van der Heijden, 2000; Schoemaker, 2002; Ralston and Wilson, 2006). Saunders (2009) mentioned the reason for scenario planning is that, among the many tools a manager can use for strategic planning, scenario planning stands out for its ability to capture a whole range of possibilities in rich detail (Schoemaker,1995).

Schoemaker, (1995) stated, by identifying basic trends and uncertainties, a manager can construct a series of scenarios that will help to compensate for the usual errors in decision making. He further explained that scenario planning is a disciplined method for imagining possible futures. It attempts to capture the richness and range of possibilities, stimulating decision makers to consider changes they would otherwise ignore. At the same time, it organizes those possibilities into narratives that are easier to grasp and use than great volumes of data. Hence, it simplifies the avalanche of data into a limited number of possible states. It helps to explore the joint impact of various uncertainties, which stand side by side equals.

Ringland (1998) defines scenario planning as “that part of strategic planning which relates to the tools and technologies for managing the uncertainties of the future”. Another important point mentioned by Porter (1985) is that scenario plans are unique from forecasting in that they are not predictions of the future but rather qualitative narratives, stories or conversations of alternative futures facing the decision-maker, and are specifically told to highlight the risks and opportunities involved in specific strategic issues. Lindgren and Bandhold (2002) added the construction of future scenarios is based on tracking the trends and events, by analysis of the interrelationships between the trends and its uncertainties, different techniques could be adopted in building a future scenario.

More importantly, Bishop et al. (2007) pointed out that the most common confusion when discussing scenarios is equating scenario development with scenario planning. They suggest that “scenario planning” has more to do with a complete foresight study, where scenario development is concerned more specifically with creating actual stories about the future. Scenario planning is a far more comprehensive activity, of which scenario development is one aspect.

### *Scenario planning techniques*

There are numerous techniques to achieve scenario planning, the following (Table 1) show the summaries of the approaches and methods in scenario planning.

Table 1. The approaches and methods for scenario planning.

<b>Authors</b>	<b>Approach/Methods</b>
Huss and Honton, (1987)	<ul style="list-style-type: none"><li>• Intuitive logics</li><li>• Trend impact analysis</li><li>• Cross-impact analysis</li></ul>
Fahey and Randall (1998)	<ul style="list-style-type: none"><li>• Global scenarios</li><li>• <b>Industry scenarios</b></li><li>• Competitor scenarios</li><li>• <b>Technology scenarios</b></li></ul>
Mats and Bandhold (2002)	<ul style="list-style-type: none"><li>• Media-based methods</li><li>• Interview-based methods</li><li>• Timeline-based methods</li><li>• Generative, intuitive methods</li><li>• Actor-oriented methods</li><li>• Consequence-focused methods</li><li>• <b>Systems methods</b></li></ul>
Ogilvy and Schwartz (2006)	<ul style="list-style-type: none"><li>• inductive approach</li><li>• <b>deductive approach</b></li></ul>
Kahn (2006)	<ul style="list-style-type: none"><li>• <b>exploratory or extend approach</b></li><li>• normative or leap approach</li></ul>

The scenario planning approach used in this study is an exploratory approach with ‘seed trends’ to construct the future. It is also a deductive approach with structured listing and prioritizing uncertainties and trends for explaining the scenarios in a 2x2 matrix. Thus, a systems method that handles multivariate relationships is needed. It can be a combination of industry and technology scenarios as well.



### *Scenarios development techniques*

Bishop et al. (2007) analyzed the current state of scenario development, with an overview of techniques and concluded 8 general categories of scenario techniques with two to three variations for each type, resulting in more than two dozen techniques overall. They included Judgment, Baseline, Elaboration of fixed scenarios, Events sequences, Backcasting, Dimensions of uncertainty, Cross-impact analysis and Modeling.

Particularly, the Dimensions of uncertainty associated with the specific concerns in uncertainty is found suitable in this study. The reason for using scenarios in the first place is the uncertainty inherent in predictive forecasting. It is never possible to have all the information; theories of human behavior are never as good as theories of physical phenomena, and finally it is needed to deal with systems in chaos and/or emergent states that are inherently unpredictable. Scenarios in this section, then, are constructed by first identifying specific sources of uncertainty and using those as the basis for alternative futures, depending on how the uncertainties play out. There are certain variations for this type includes: morphological analysis, field anomaly relaxation, GBN (Global Business Network), MORPHOL and OS/SE (Option Development and Option Evaluation). This technique is best for considering alternative futures as a function of known uncertainties, but it is less creative because it may not consider some novel developments that are not currently considered uncertain. (Bishop et al., 2007)

In this study, GBN matrix is the technique adopted in developing the scenarios. GBN matrix has become the default scenario technique since Schwartz (1991) published his best-seller, *The Art of the Long View*. The matrix is based on two dimensions of uncertainty or polarities. The four cells represent alternatively the four combinations of the poles of the two uncertainties, each of which contains a kernel or logic of a plausible future. Each kernel is then elaborated into a complete story or other presentation, and the implications for the focal issue or decision are discussed. GBN provide the right mix of technical sophistication and ease of use for professional audiences which make it dominate in scenario development. Yet, it is almost impossible to fully characterize the uncertainties of the future with just two dimensions. (Bishop et al., 2007)

The 2x2 matrix is developed with two uncertainties and divides the scenarios model in four quadrants. Lindgren and Bandhold (2002) mentioned the matrix provides a way to handle uncertainties, in the scenario building process, there are often a number of trends that are likely to have a great impact on the main subject, but are uncertain and not easily predictable. The first step in the scenario building process is to pick out two

driving uncertainties that are considered together in a scenario cross. Then, four different scenarios will come out in the corners of the cross.

### 2.3. Research process

In scenario planning, there are certain processes identified by different researchers. A traditional scenario planning process includes the following steps (Schoemaker, 1995):

1. Define the scopes
2. Identify the major stakeholders
3. Identify basic trends
4. Identify key uncertainties
5. Construct initial scenario themes
6. Check for consistency and plausibility
7. Develop learning scenarios
8. Identify research needs
9. Develop quantitative model
10. Evolve towards decision scenarios

These processes are however too long and complex, some steps could be simplified. In this paper, in order to adopt the scenario planning approach as the methodology, the research process is following the scenario planning steps as in Figure 1:

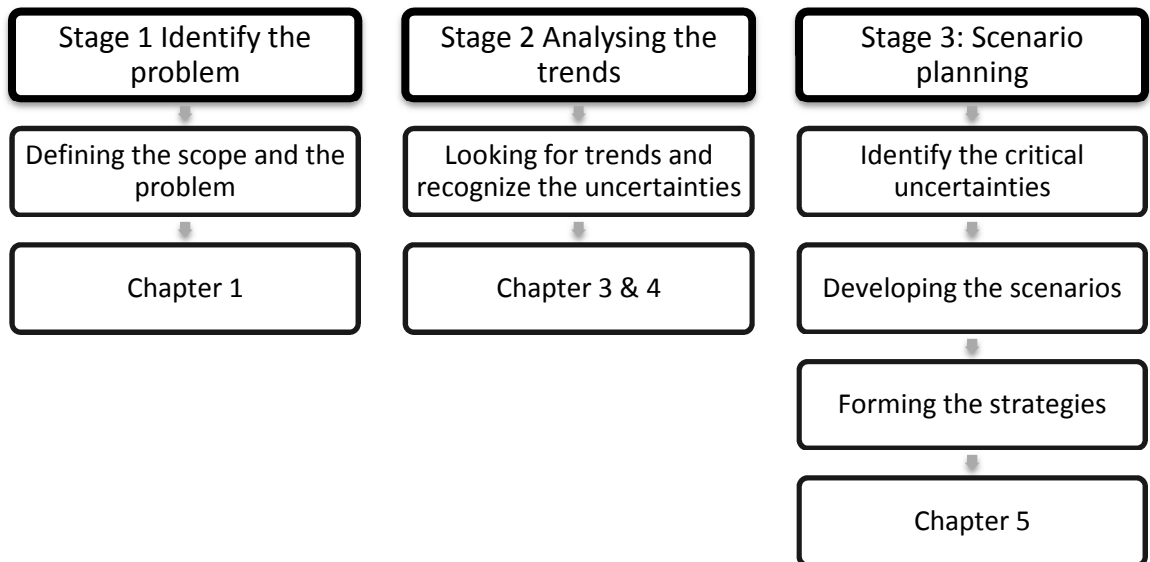


Figure 1. The research process associated with scenario planning.

The first stage is to define the scope and the problem in the garment assembly manufacturing, and consider the future development. The research problem comes from

the point of view of the author of LEAPFROG project in European Union, in response to the motivation of automation in garment assembly. It is thus evolving to the idea of future scenarios.

The second stage is to look into the current situation and trends concerning the manufacturing assembly aspect, with special focus on automation and outsourcing strategies. The theories regarding the manufacturing strategies basically come from the literature reviews; it is later on the ground of the strategy recommended in stage three. With the two alternatives identified for garment assembly manufacturing, an analysis focus on the garment manufacturing industry is carried out. The uncertainties could be thus recognized at the same time in this stage. The data collected is then used for analysing under the garment assembly manufacturing aspect.

Hence, in stage three the concrete scenario development process is carried out. By analysing the uncertainties in stage two, the two residual uncertainties are identified. They are thus continuing to the building of scenarios with the GBN dimensions of uncertainty techniques in a 2x2 matrix. Finally, actions for scenarios are recommended with the strategic postures and move.

## **3. ALTERNATIVES FOR ASSEMBLY MANUFACTURING**

In chapter 3, the main objective is to find the alternatives for manufacturing especially for assembly operation. Among many manufacturing best practices, they can be viewed as manufacturing strategies in this aspect. In considering assembly, outsourcing and automation are the two strategies for manufacturing in many industries. They are explained in the manufacturing aspect and the strategies used in outsourcing and automation for achieving the manufacturing efficiency are also investigated.

### **3.1. Manufacturing strategies in general**

#### **3.1.1. Assembly manufacturing in business**

Manufacturing is a traditional activity in business trade. It is the principal activity in the secondary industries, which convert the raw material into products. In the technical aspect, manufacturing can be defined as the application of physical and chemical processes to alter the geometry, properties and or appearance of a given starting material to make parts or products. The processes that accomplish manufacturing involve a combination of machinery, tools, powers and manual labor. (Groover, 2008) Accordingly, manufacturing processes can be divided into processing operation and assembly operation. A processing operation transforms a work material from one state of completion to a more advanced state that is closer to the final desired part or product. An assembly operation joins two or more components to create a new entity, which is called an assembly. In other words, manufacturing also includes the joining of multiple parts to make assembled products.

Mathew and Rao (2010) mentioned that assembly is one of the most important activities in the manufacture of a product because of its complex nature. More than 30 percent of total industrial product labour costs are attributed to the cost of the assembly (Nevins and Whitney, 1978). Nof et al. (1997) also pointed out that assembly of manufacturing goods accounts for over 50% of total production time (Nevins and Whitney, 1978) and for 20% of total unit production cost (Martin-Vega et al., 1995). They explained the relative importance of assembly in terms of time and cost of assembled products, potential savings can be generated by efforts to improve assembly technology and systems.

In this paper, the focus will be in the assembly operation. It is usually the final set of operations of the products and traditionally labour intensive and considerably affected by globalization (Onori and Oliveira, 2010). In the early decades, manufacturing was a core function in many companies. Today, manufacturing is still an important commercial activity. The difference from the past is that most of the manufacturing activities are carried out by others companies. One of the major reasons is the increasing cost of production. Especially for assembly operations, because of its labour intensive process, the high labour cost force companies to minimize the involvement in manufacturing and shift the whole or part of the assembly activities to an outsider, which is regarded as outsourcing.

Yet, no matter how companies settle the manufacturing activities, the ultimate goal is to strengthen the competitiveness for their business. From the business point of view, managers regarded manufacturing as the competitive strength and a competitive weapon (Roth and Miller, 1992; Hayes and Clark, 1995). Säfsten et al. (2007) pointed out that manufacturing is one of the several functions that have to support the achievement of the overall objectives for a company. Nevertheless, manufacturing add values to materials by changing its shape or properties and combining it with other materials that also have been altered, the product is thus of greater value by means of one or more processing and assembly operations. (Groover, 2008)

Indeed, the goal of manufacturing can be explained in certain aspect. Skinner (1969) proposed that the manufacturing objective includes cost, quality, delivery and flexibility. These objective criteria could be predetermined specifically by each individual company in measureable unit. These four elements are also regarded as the competitive capabilities in which findings suggest that a balance between cost efficiency and flexibility is built upon high levels of quality and delivery performance (Hallgren et al., 2011). Cost efficiency, quality level and delivery dependability in respect of lead time and responsiveness for on-time delivery are foundation concepts. Flexibility is the ability of a manufacturing system to cope with changing circumstances or instability caused by the environment. (Gupta and Goyal, 1989) It helps to cope with environmental uncertainty (Swamidass and Newell, 1987). The varieties of flexibility types include machine, process, product, routing, volume, expansion, operation and production flexibility (Browne et al., 1984). The types of flexibility can be associated with uncertainties as mix, changeover, modification, rerouting, volume, material and sequence flexibility. (Gerwin, 1987)

The goal of manufacturing is actually allied with the goal of business. The ultimate objective is to strengthen the competitiveness of the business. Particularly improving the manufacturing efficiency, by minimizing the cost and increasing the productivity can be

a simple and common goal of manufacturing. It eventually increases the business performance to compete with the competitors.

### **3.1.2. The concept of manufacturing strategy**

The goal of manufacturing has to be accomplished by the decision of certain plans and actions, and these combinations of decisions form a strategy. Chandler (1962) defined strategy as the basic long term goals and the objectives of a company, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals.

#### *Defining manufacturing strategy*

Starting from the pioneer Skinner (1969)'s definition, manufacturing strategy exploiting certain properties of a manufacturing function as a competitive weapon. Hayes and Wheelwright (1984, 1985) added manufacturing strategy also consists of a sequence of decisions that over time, enables a business unit to achieve a desired manufacturing structure, infrastructure and set of specific capabilities. Swamidass and Newell (1987) further explained manufacturing strategy is the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals. Platts and Gregory (1990) stated a manufacturing strategy defines how manufacturing will assist in the achievement of the business objectives through the provision of appropriate structural items, (buildings, plant and equipment, etc.) and the appropriate infrastructure (manning, organization, control policies, etc.) to ensure that operations are effective.'

In summary, according to all these definitions, manufacturing strategy should include a number of decisions for plans and actions to achieve the objectives and goal of the overall strategy in the business. The goal should be first determined before the decisions of plans and actions. Blindly follow the best practices or strategy is not helping to solve the problem.

#### *Perspectives of manufacturing strategy*

Besides, the strategy for manufacturing can be view in two different perspectives (Figure 2). Here, the example of 'Automation strategy' by Säfsten et al. (2007) is used to explain. The first perspective is when the overall manufacturing strategy is equal to an automation strategy, in other words, the strategy is automation. The other perspective is when decisions concerning automation are treated as one of several decisions in a manufacturing strategy and this perspective is proved to be more successful.

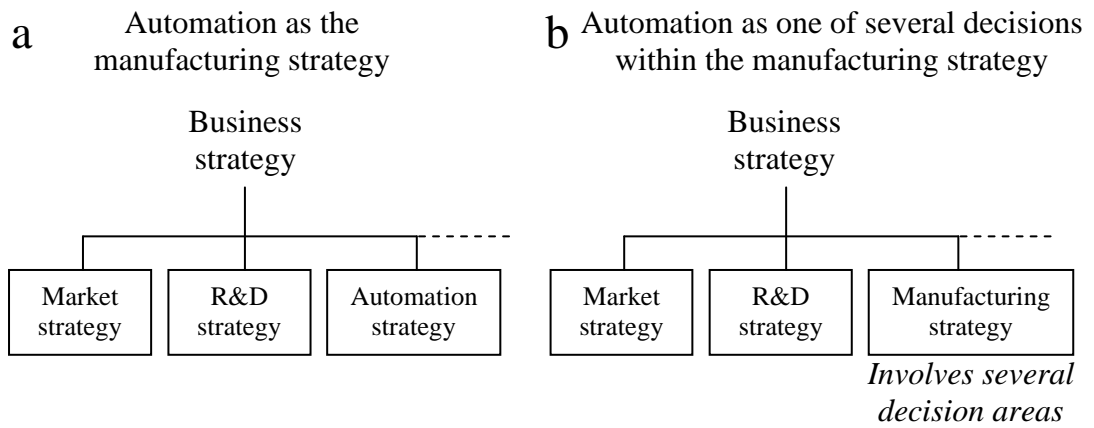


Figure 2. Two perspectives of automation as manufacturing strategy. (Säfsten et al., 2007)

Moreover, the position of manufacturing strategy in an organization reflects its importance to the overall organization's decision making and hence the final result. Hofer and Schendel (1978) introduced the hierarchy of strategy in an enterprise. The three levels of strategy decision are classified and defined as follow:

- Corporate strategy: What set of businesses should we be in?
- Business strategy: How should we compete in XYZ business?
- Functional strategy: How can the function contribute to the competitive advantage of the business?

Within this hierarchy, Mills et al. (1995) suggests that manufacturing strategy can appear in two places, first at the corporate level, taking a broad view over a set of related or separate businesses. Second, it can appear as one of the functional strategies at the business level as shown in Figure 3.

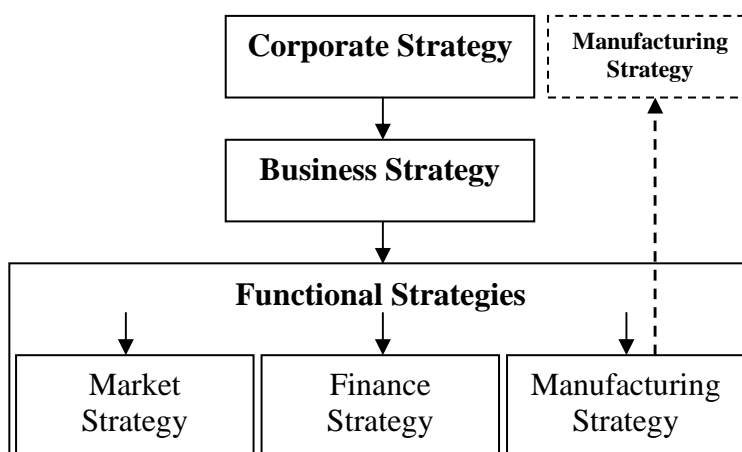


Figure 3. Position of manufacturing strategy.

Even though manufacturing strategy could appear in corporate level, it is commonly agreed that manufacturing strategy is a functional strategy within the literatures. (Skinner, 1969; Hayes and Wheelwright, 1984; Platts and Gregory, 1990; Hill, 2000) Manufacturing strategy supports the business strategy of a company together with other functional strategies such as marketing, research and development and accounting. It has a consistent pattern of decision making in the manufacturing function which is linked to the business strategy. (Hayes and Wheelwright, 1984, 1985)

Nevertheless, a manufacturing strategy should be coordinated with the overall corporate strategy of a company as well. Fine and Hax (1985) proposed that manufacturing strategy is an important part of a company's business strategies, comprising a set of well-coordinated objectives and action programs aimed at securing a long-term, sustainable advantage over competitors. Thus manufacturing strategy should be consistent with the firm's overall strategies, as well as with other functional strategies. Hill (1987, 1989) described manufacturing strategy in a coordinated approach, which strives to achieve consistency between functional capabilities and policies for success in the marketplace. He supported with the view that since manufacturing strategy does play a part in manufacturing success and thus business success, therefore, it is important that manufacturing strategy aligned with business strategy. Moran and Meso (2008) further agreed with an addition comment that manufacturing affects overall business strategy, and business strategy affects manufacturing. In other words, it means the manufacturing and its strategy correlative to the overall business, and vice versa. In summary, manufacturing strategy is a part of functional strategy and it also influence to the overall strategy.

### **3.1.3. Different practices in manufacturing strategy**

Manufacturing strategy can be divided into strategy content and strategy process (Swink and Way, 1995). 'Content' refers to the collection of decisions (Slack and Lewis, 2002), which can be viewed as in terms of changes to the structure and infrastructure of a company, made with the intention of fulfilling manufacturing objectives. 'Process' includes design, developments and implementations of manufacturing strategy. (Dangayach and Deshmuck, 2001) However, this paper will not go into details of how the manufacturing is constructed, therefore, the focus would be on the content of manufacturing strategy only.

The contents of manufacturing strategy have been viewed as the strategic choices in process and infrastructure. Dangayach and Deshmukh (2001) summarized the content of manufacturing strategy and identified three broad approaches: manufacturing capabilities, strategic choices and best practices. In which, best practices approach is more similar to described what are the different types of strategy in manufacturing.



The best practices in manufacturing strategy include manufacturing resource planning, optimized production technology, flexible manufacturing system, group technology, total quality management, just-in-time, lean production and concurrent engineering. Moreover, Hayes and Wheelwright (1985) gave the concept of world class manufacturing (WCM).

### *Practices as Strategy*

As discussed earlier, a manufacturing strategy can include several decisions and combinations of practices. Many researches have been focus on best practices in manufacturing strategy. In fact, these are common practices in the manufacturing context, to define whether they are the 'best' or not, it should be corresponding to the goal and objectives of the business itself. Indeed, these 'practices' are usually consists of plans and actions which designed to achieve the long term goals and objectives of the company. Therefore instead of using the term 'practice', entitling them as individual strategy in manufacturing strategy would be more suitable in this study.

Manufacturing strategy includes a group of old and new manufacturing practices, Bolden et al. (1997) outlines taxonomy of modern manufacturing practices with 87 matrixes (Figure 4). From these practices, automation and outsourcing are categorized into different area.

In the fashion industry, many practices are also included in Figure 4, such as JIT, QR, Lean production etc. Yet, considering garment assembly process, outsourcing and automation, these two strategies have different focus, they are interpreted as alternatives in manufacturing under this specific garment industry context, as they have the result and root cause relations, i.e., because of automation is not well developed yet in garment assembly, outsourcing is widely practiced in the garment manufacturing industry. Thus, outsourcing and automation will be discussed under the manufacturing strategy context in the following chapter.

In related to plant performance, Bengtsson and Dabhilkar (2009) argued on an alternative strategy to outsourcing is to invest in manufacturing capability. They emphasis that outsourcing could not be regarded as an alternative to develop further internal manufacturing capability. It is consistent with Laugen et al. (2005) point of view that technological and organizational investment in manufacturing has significant impacts when comparing performance outcomes. In order to become successful, plants may use outsourcing, not as an isolated and alternative strategy, but rather in combination and as a complement to further develop internal manufacturing capacity and capability. (Bengtsson and Dabhilkar, 2009)

A.	Business-focus			Organization-focus	
	B.	C.	Primary domain of application (below)	D.	E.
Improved quality	Reduced cost	Responsiveness to customers		Improved technology	Employee development
Quality Standards Statistical process control Total productive maintenance Quality function deployment Mistake proofing	Reduced work progress Just-In-Time production Process mapping Smart design Re-usability Product rationalization	Rapid prototyping Concurrent engineering Customer Involvement in design Lead time reduction Agile manufacture	1.Design and production	Computer-aided process planning and control Computer-integrated manufacturing systems <b>Automation</b> Computer-aided design and engineering	Job rotation Multi-skilling Psychometrics Appraisal Training and development Suggestion schemes Attitude surveys Secondments Safety management
Supply chain partnering Customer feedback Conformance checks	Reduced Inventory Single sourcing Just-In-Time Inventory control Forecasting Logistics management	Predicting customer requirements Maintaining stock levels	2.Inventory and stock	Automated storage and retrieval systems Electronic data Interchange	Product team responsibility for purchasing and distribution
Quality improvement teams Operator responsibility for quality Quality feedback to operators Quality training Ergonomic design	Downsizing Delaying <b>Outsourcing</b> Casual labour	Flexible work organization After-sales support Cellular manufacture	3.Work organization	Flexible manufacturing systems Group technology Computer-supported co-operative work Manufacturing resource planning	Harmonization Team-based work Job enrichment Boundary management
Total quality management Quality awards Quality gurus World class manufacturing Benchmarking for quality	Lean production Cost management Financial performance measures Time-based management Benchmarking for costs	Priority given to customers Market research Customer surveys Benchmarking for customer responsiveness Business process re-engineering	4.Wider organization of manufacturing	Technology strategy for entire company Computer-based management tools Benchmarking for technology	Explicit company HRM strategy Employee empowerment Performance-related pay Culture change Learning climate Investors in People Benchmarking for employee effectiveness

Figure 4. Modern common manufacturing practices. (Bolden et al., 1997)

Furthermore, regarding the European automation assembly for manufacturing, the industry will increasingly have to rely upon more extensive outsourcing or cost-effective automation technologies. (Onori et al., 2003 in Onori and Oliveira, 2010) The rapid decline in labour force and resulting narrowing the skill base has been well defined by Bagavos and Martin (2000) and constitutes a catalyst to the problem just defined. This may be considered a vital challenge for all sectors of the society in Europe, the alarming issue is the steady decline in births in Europe, which will inevitably lead to a lack of available workforces. (Onori and Oliveira, 2010)

## **3.2. First alternative: outsourcing**

### **3.2.1. Manufacturing outsourcing**

Outsourcing is basically the make or buy decision. It is defined as having activities that were formerly done inside the organization now performed by an external supplier (McIvor, 2005). From a purchasing perspective, it is defined as ‘outside resource using’ (Gilley and Rasheed, 2000). The most common is the original equipment manufacturers (OEMs) in a wide range of industries have increasingly favored buying finished product from contract manufacturers over making the product themselves (Edmondson 2003, Hayes 2002, Reymond 2006). It is so common that almost everything can be outsource, not only the traditional manufacturing process, but also other business activities such as research and development, IT and even sourcing itself.

Gilley and Rasheed (2000) proposed two generic types of outsourcing: peripheral outsourcing and core outsourcing. The first type occurs when firms acquire less strategically relevant, peripheral activities from external suppliers. The second type occurs when firms acquire activities that are considered highly important to long-run success. What constitutes a core or peripheral activity is essentially a judgment by each individual firm, based on what it considers as its core competency and the strategy it intends to pursue.

Moreover, Gilley and Rasheed (2000) suggested outsourcing can arise in two ways: substitution based and abstention based. The substitution-based outsourcing can be viewed as a discontinuation of internal production and an initiation of procurement from outside suppliers, which can be viewed as vertical disintegration. The abstention-based outsourcing arise when a firm purchases goods or services from outside organizations even they have not been completed in-house in the past. Both outsourcings reflect a decision to reject internalization.

Manufacturing outsourcing involves acquiring manufacturing components and value-creating activities from external sources rather than performing them internally (Lei and Hitt, 1995; Beaumont and Sohal, 2004). The outsourcing trend has led to a flourishing

business for “contract manufacturers”, companies that offer to produce part or entire ranges of products, which mean major company outsources manufacturing and most of its assembly to a specialized contract manufacturer. (Onori and Oliveira, 2010)

It is essential to emphasize that outsourcing is not necessary to be overseas. In accordance with outsourcing, there are few correlated concepts such as offshoring, or near-offshoring. Basically, outsourcing means shifting manufacturing activities to external suppliers while offshoring refers to off-shore sourcing, sourcing from an internal or external supplier located abroad (GAO, 2004). Kumar et al. (2010) stated that outsourcing can be in both the home country of the company, as well as abroad, and entails an organizational restructuring of some activities. Outsourcing is a conscious abdication of selected value chain activities to external providers. Offshoring, on the other hand, is restructuring the firm geographically. In fact, most of the companies in the fashion industry adopt offshore outsourcing, mainly due to the high domestic labour cost.

### **3.2.2. Motivation and consequences for manufacturing outsourcing**

There are different motivations for companies to adopt outsourcing as their manufacturing strategy. The main rationales for outsourcing concern expectations regarding the reduction in operating costs and the focus on core competencies and ambitions to learn from innovative suppliers (The Outsourcing Institute, 2005). Below are the six major reasons: *cost reduction, focus on core competence, access new knowledge, increase flexibility, reduce risk and explore foreign market.*

#### *i. Cost reduction*

The motivations for outsourcing related to cost issues are under the transaction cost category. It is not doubt that the primary reason for outsourcing is cost reduction. (Baldwin et al., 2001; Zhu et al., 2001; Doh, 2005; Farrell, 2005; Rasheed and Gilley, 2005; Bengtsson and Dabhilkar, 2009) Reduction in labor and production costs is especially common in order to increase revenues. (Sanders et al., 2007) Donna and Rossitza (2010) find that firms in the manufacturing sector are more likely to outsource if they have relatively higher labor costs. It is not only savings on wage, but also benefit payments (Abraham and Taylor, 1993). In addition to cost reduction, it is another point of view in improves efficiency (Kumar et al., 2010).

#### *ii. Core competence*

The core competences approach advocates that firms should outsource those activities in which they do not have core competences (Quinn and Hilmer, 1994). Firms may choose to outsource if they lack resources and capabilities (Grant, 1991). Hamel and Prahalad (1990) stated that the plant’s core competencies have three characteristics:

they are unique and differentiate the plant from its competitors; they are sustainable and hard to copy; and they may be used in different products and markets. Concentrate on core competence and differentiation is a more strategic motivation for outsourcing, because it increases the opportunities to access new competencies and establish faster product development. (Medina et al. 2005; Kakabadse and Kakabadse 2005; Baden-Fuller et al. 2000; The Outsourcing Institute, 2005)

Williamson (1991) proposed that the most decisive factor whether to outsource or not is asset specificity. The basic idea is different assets and investments are more or less unique and specific to a certain plant. Thus, high specificity assets and competencies should be kept in-house because they are deeply embedded in existing operation process, low specificity assets could be outsourced.

*iii. Access new knowledge*

The third reason for outsourcing is to access new knowledge. Kumar et al. (2010) mentioned outsourcing can provide opportunity to exploration or access to knowledge and talented people Abraham and Taylor (1993) suggested outsourcing can access to specialized skills and inputs that the organization cannot itself possess. Companies can buy technology from a supplier that would be too expensive to replicate internally (Carlson, 1989; Harrison, 1994; Domberger, 1998). Hence, the knowledge can be in any format such as technology, management, or experiences.

*iv. Increase flexibility, capacity, quality, responsiveness*

Outsourcing provides companies with greater capacity for flexibility (Carlson, 1989; Harrison, 1994). A network of suppliers could provide an organization with the ability to adjust the scale and scope of their production capability upward or downward, at a lower cost, in response to changing demand conditions and at a rapid rate. (Carlson, 1989; Harrison, 1994; Domberger, 1998). Outsourcing improves the organization's responsiveness and "leads to the availability of higher quality goods and services by creating competition among suppliers" (Rasheed and Gilley, 2005).

*v. Reduce risk*

Risks can be reduced in many aspects. Abraham and Taylor (1993) pointed out outsourcing can transfer the demand uncertainty to the outside contractor. Besides, it can reduced risks when decreased capital investment requirements (Simchi-Levi et al., 2003; Rasheed and Gilley, 2005; Lyons and Farrington, 2006).

vi. *Explore foreign market*

Kumar et al. (2010) added outsourcing allow company to ‘exploitation’ or development of foreign markets (Dunning, 1993). Hence, offshore-outsourcing different from inshore outsourcing in a way that relocation of operations abroad helps the MNC to better understand and exploit foreign markets.

In summary, for manufacturing assembly, even though outsourcing comes with lots of the advantages, not all of them are the major driving forces that encourage a company to involve in outsourcing. It is clear that cost reduction is the primary motivation and labour cost is the major part. Secondly, as assembly process is not the core competence for many companies it is another reason to focus in their core competence and outsource assembly manufacturing. Furthermore, networking with other industrial partners in order to learn additional knowledge such as technological and business aspect, and also to explore the foreign market are supplementary reasons for outsourcing.

*Consequences*

Despite of the attractiveness of outsourcing, there are plenty of consequences associated with outsourcing. They are considered unexpected, hidden and even in contradiction of the motivation of outsourcing for many companies. They can be identified under certain risks: hidden cost, loss of control, loss of flexibility, loss of knowledge and skills, unemployment.

i. *Hidden cost*

Christopher et al. (2004) pointed out that the empirical research has shown that sourcing offshore can have negative consequences; once the hidden and inflexibility costs are quantified, (Lowson, 2001).

Hidden costs are those that are not typically anticipated by the buying organization, but almost always occur. Some examples include (Christopher et al., 2004):

- the various initial investments to establish the new source of supply, control of quality and delivery variables;
- high initial training costs, coupled with a high staff turnover affecting both throughput and quality;
- significantly lower operator efficiency offshore;
- irrevocable letters of credit charges;
- delays at the port of entry, last minute use of air freight and other logistics costs;
- expensive administrative travel to correct problems; process inefficiencies and quality problems;

- long lead times and the need for large buffer inventories; and
- the not insubstantial human cost involved in the conditions endured in many foreign factory environments often employing child labour and over-using natural resources.

Inflexibility costs are the costs of using suppliers that are inflexible and unresponsive to changes in demand (before, during and after a product selling season), leading to disproportionate levels of demand amplification across a longer supply network and a number of considerable cost implications. (Christopher et al., 2004)

Instead of cost reduction, costs increased (McCarthy and Anagnostou, 2004) , which is normally regarded as the hidden cost from outsourcing. It is noticeable that many outsourcing arrangements fail to deliver the expected cost savings, the major reason is the management has not calculate the total cost of outsourcing (Juras, 2008). Instead of production costs, the costs factors also included the costs incurred in managing the transaction, which includes finding a supplier, managing supply relationships and evaluating the impact of the outsourcing decision on the firm (Paresha et al., 2011). Other additional costs include those associated with staff training and monitoring to communicate with overseas suppliers (Ellram et al., 2008), increased costs of travel and transportation (Rasheed and Gilley, 2005), and extra costs of market-based transactions (Gilley and Rasheed, 2000). Furthermore, outsourcing leads to a re-definition of organizational boundaries and, by implication, structural adjustments involving human resources, these changes incur social as well as financial costs. (Domberger, 1998; Hall and Domberger, 1995).

*ii. Loss of control*

When the outsourcing decision is made, the company is losing control in manufacturing, as they are loss of control over suppliers (Domberger, 1998; Quinn and Hilmer, 1994). Not only the loss of management control (McCarthy and Anagnostou, 2004), another typical example is quality control, it happen especially when quality standards are not stipulated in the contracts with suppliers (Kaya and Özer, 2009). In the worst case, the companies tend to be over-dependence on suppliers due to customized arrangements in outsourcing (McIvor, 2005)

*iii. Loss of flexibility*

Because of the loss of control, outsourcing lead to the reduction in flexibility (McCarthy and Anagnostou, 2004). Outsourcing has a risk in the loss of flexibility. Dr. Kam et al. (2011) mentioned that as entering into a long-term contract with outsourcer could lessen an organization's flexibility because changes in business requirements or technology may render the contractual terms obsolete. It could reduce responsiveness and risk of

alienating customers. (Embleton and Wright, 1998; Beaumont and Sohal, 2004; Shi, 2007). Loss of flexibility (Beaumont and Sohal, 2004) is a risk particularly if suppliers disrupt their operations (Sanders et al., 2007).

*iv. Loss of skills and knowledge*

Outsourced induce to the loss of critical skills, the loss of cross-functional skills (Domberger, 1998; Quinn and Hilmer, 1994), especially when the manufacturing process is not running within the organization anymore. Leavy (2004) pointed out that the risk of losing skills that could be a key to compete in the future. In the long run, a decline in innovation is another associated risk of outsourcing (Gilley and Rasheed, 2000; Rasheed and Gilley, 2005) which can reduce competitiveness. If an outside supplier gains new technologies and improves their innovation capacity they may become future competitors (Gilley and Rasheed, 2000; Rasheed and Gilley, 2005).

*v. Unemployment*

Because of manufacturing outsourcing, the workers in the assembly lines would be either lay off or transferring to other department. It eventually leads to the result of unemployment. According to the research by Ellis and Lowell (2003), McKinsey & Co., the USA, Europe and Japan are losing approximately 600,000 jobs/year within the manufacturing sector, a fact rendered even more serious by the Gartner, Inc. study, which notes that this trend is likely to maintain its course until 2010 and result in the loss of 25 per cent of high- technology jobs to emerging markets in India, China and elsewhere (British Computer Society, 2005). The unemployment effect is serious especially in the developed countries. In social aspect, outsourcing can lead to industrial disputes between employers and employees, which in turn can damage morale, trust and productivity (Domberger, 1998; Quinn and Hilmer, 1994).

*Motivation or consequences?*

Despite many discussions, it is confusing that some benefits or motivation of assembly outsourcing are actually projecting some inverse effect to the overall business. Figure 5 summarize their contradiction in a clearer aspect.



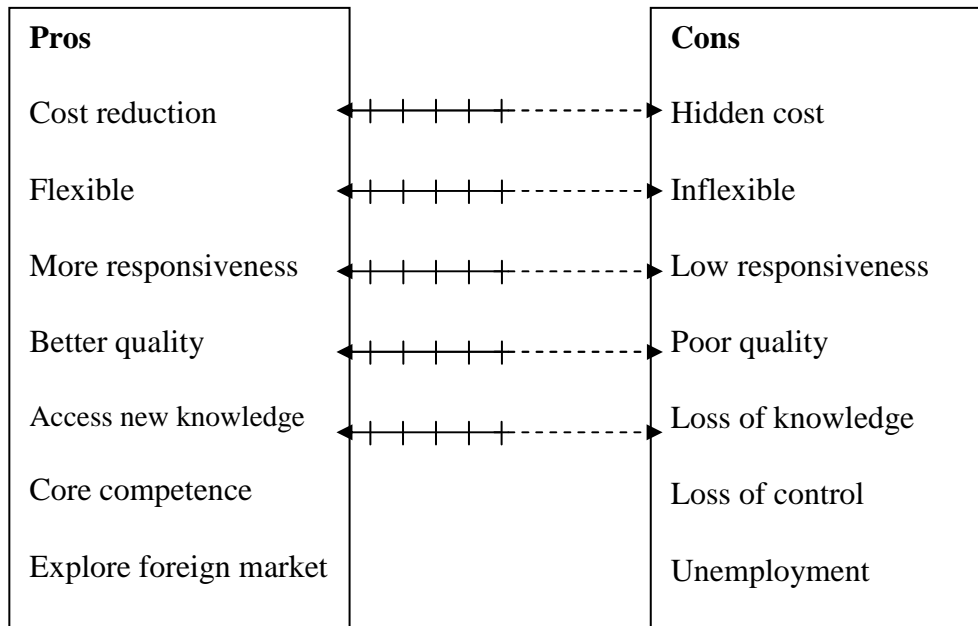


Figure 5. Pros and cons of manufacturing outsourcing.

Apart from specific features for core competence and explore foreign market, as well as loss of control and unemployment for pros and cons respectively in addition to the knowledge aspect. The contradictions can be classified into costs, flexibility, responsiveness and quality, which are correlated to the manufacturing objectives. It will be discussed in the later chapter.

### 3.2.3. Outsourcing strategies

In order to manage the outsourcing risks in apparel industry, Dr. Kam et al. (2011) analyzed the literatures discussing approaches to deal with outsourcing failures from the risks management perspective. These six approaches include: internal enhancement prior to outsourcing, supplier selection and management, selectively managing a network of outsourcing partners, contract management, enterprise risk management, relationship management and ICT infrastructure aid.

Leavy (2004) mentioned that the earliest outsourcing strategies were largely driven by the desire to lower costs in the face of intensifying global competition, typically by moving low-skilled, labor-intensive, activities offshore to South-East Asia and other low cost locations. In more recent years, there has been a growing awareness of the potential of outsourcing to support a range of strategies beyond that of lower cost. He proposed that outsourcing as a strategy has the potential to drive competitiveness and value creation in many ways beyond the narrow goal of cost reduction alone. He further suggested four of the most promising opportunities for using outsourcing strategies: focus, scale without mass, disruptive innovation, and strategic repositioning. Even

though, these are just four of the many promising options that outsourcing as a strategy can offer and support.

### *Supplier relationship management*

Regarding the cost issues, as Agrawal et al. (2010) and Bahli and Rivard (2005) have noted, firms may not consider the unexpected hidden costs of the transaction. The companies are locked into an inefficient or unreliable supplier, having to renegotiate contracts and disputes and litigation arising from the changes in the management or ownership of the firm. (Paresha et al., 2011)

The above issues normally arise from insufficient management of supplier and maintenance of supplier relationship. As McCarthy and Anagnostou (2004) mentioned, competitive outsourcing requires a high standard of supplier management to avoid the pitfalls of transferring critical functionality, or becoming too dependent on a supplier for day-to-day performance of vital business functions. The monitoring of suppliers is a key to outsourcing success. A portfolio approach to manage the supplier relationship is promoted by Olsen and Ellram (1997), the portfolio includes Non-critical, Leverage, Critical and Strategic. Four basic supplier strategies are applicable for the different segments of the portfolio, they are partnership, competitive bidding, secure supply and system contracting (Weele, 2000). More importantly, building up trust between buyers and suppliers is a key to maintain a long term relationship.

### *Supplier strategies*

Sourcing strategies derive from a basic decision to buy rather than make (Seshadri, 2005). When outsourcing is decided, it directly turns to the decision in sourcing activities. One of the most common decisions is the selection of suppliers and how many suppliers should be sourced. Some common strategies include single sourcing, dual sourcing, double sourcing and multiple sourcing.

Sole sourcing is related to single sourcing but differ from single sourcing in a way that the supply base contains only one supplier; whereas single sourcing is when a buyer chooses a single supplier even though other comparable suppliers existing in the supplier base (Newman, 1989). Single sourcing has benefit in creating sole-supplier partnerships to support programs such as just-in-time and quick response. (Tyworth and Ruiz-Torres, 2000) Dual sourcing indicates that a buyer employs two suppliers, one of which may dominate the other in terms of business share, price, reliability, and others (Tullous and Utecht, 1992). Selecting dual rather than single sourcing (Warburton and Stratton, 2002) is a tactics for supply risk mitigation. Multiple sourcing means a buyer does business with several suppliers and replace one supplier with another to enjoy the best price advantage. (Tullous and Utecht, 1992) “Multisourcing” is particularly

interesting when suppliers with similar capabilities provide similar services to a client; industry analysts have encouraged firms to adopt multisourcing by forecasting major cost savings and operational and strategic risk reduction. (Cohen and Young, 2006)

Double sourcing is the use of one close, quick and expensive supplier and of one distant, slow and inexpensive supplier for the very same garment (Forza and Vinelli, 2000; Perry and Sohal, 2000; Christopher and Towill, 2002; Jin, 2004). Double sourcing allows for low-cost sourcing from distant supply markets and at the same time for responsiveness, it is associated with the concept of 'quick response' as a sourcing strategy. (Åkesson et al., 2007)

#### *Partial outsourcing*

Partial outsourcing is wherein the OEM simultaneously produces in-house and procures, can be an optimal strategy. (Gray et al., 2009) With partial subcontracting, the firm decides to outsource only a certain proportion of the required components (Shy and Stenbacka, 2005). By adjusting the production mode towards more in-house production, the firm induces savings with respect to the fixed monitoring costs and relaxes the intensity of competition in the market for final goods. These findings apply to markets with homogeneous final goods under quantity competition as well as to markets with differentiated products under price competition. (Shy and Stenbacka, 2005)

### **3.3. Second alternative: automation**

#### **3.3.1. The concept of automation**

##### *Definition*

Automation has different definitions depending on approach and context. Satchell (1998) defined Automation is the replacement of human activity by machine activities. Encyclopædia Britannica Online (2006) described Automation as the application of machines to tasks that was performed by human beings before or the tasks that is impossible to perform by humans. Automation is also regarded as the use of automated equipment compensates for the labor cost disadvantage relative to international competitors. (Groover, 2008) Basically speaking, Automation is a substitute of manual labour by the mean of machinery.

##### *Automation Assembly*

Riley (1983) proposed Automation assembly is a high production tool available to high volume manufacturers to reduce two major expense areas, product assembly and product quality. He said it is an optional capital investment on the part of management. Some areas of manufacturing require the purchase of fabricating machines. A

management decision of manufacture a product in high volumes mandates the purchase or rental of fabricating equipment. The availability of relatively inexpensive and unskilled labor is an optional management choice for most types of assembly work, and this choice requires little or no capital investment. Its broadest applications will come where production of products is measured in millions of annual units of production. These volumes maybe made up of a family of similar products, particularly if the sequence of assembly is common. Larger products, such as cars and larger appliances, may not need such high rates of annual production for economic justification. Products with high quality requirements and products with seasonal demand may justify mechanized assembly on lower volumes.

*Level of Automation (LoA)*

For instance, Automation can be done fully or partly. The relationship between humans and technology can be viewed as a continuum from fully manual to fully automatic by approaching the sharing of tasks between the human and technology (Frohm, 2008). This concept is called levels of automation (LoA) as in Table 2:

Table 2. The reference scales for Level of Automation (LoA) (Frohm et al., 2008).

LoA	
1	Totally manual
2	Static hand tool
3	Flexible hand tool
4	Automated hand tool
5	Static machine/workstation
6	Flexible machine/workstation
7	Totally automatic

This is a concept which refers both to mechanize and cognitive tasks allocated between the human and technical equipment and ranges from 1 to 7 on a reference scale (Granell et al., 2007; Frohm, 2008). Zandin (2001) added semi-automated operations are those in which the worker plays a substantial role in the activity. The worker's role exceeds that of supplying the automated equipment with parts or materials, or removing finished parts from the work area. To date, the preponderance of factory operations has actually been semi-automated rather than fully automated, because the worker-machine combination is often the most efficient and effective in involved tasks.

*Three types of automated manufacturing system*

Groover (2001) classified three basic types of automated manufacturing system. First, fixed automation which is a system in which the sequence of processing or assembly operations is fixed by the equipment configuration. The second one is programmable

automation, the production equipment is designed with capability to change the sequence of operations to accommodate different product configurations. The third one is flexible automation, it is an extension of programmable automation which is capable of production a variety of parts or products with virtually no time lost for changeovers from one part style to the next. These three types of automation can be classified relative to production volume and product variety as in Figure 6.

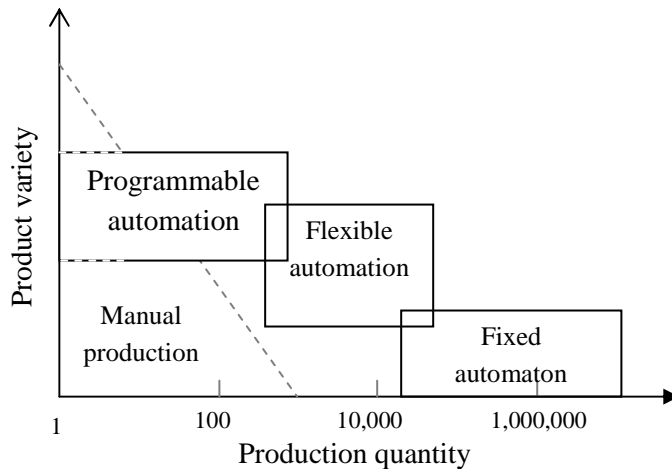


Figure 6. Three types of production automation relative to production quantity and product variety. (Groover, 2001)

In addition, these three types of production automation can be compared in terms of initial investment, production rates, flexibility and production type as in Table 3.

Table 3. The comparison of three type of production automation (Groover, 2001).

	<i>Initial investment</i>	<i>Production rates</i>	<i>Flexibility</i>	<i>Production type</i>
<b>Fixed automation</b>	high initial investment for custom-engineered equipment	high production rates	relatively inflexible in accommodating product variety	fixed type of product
<b>Programmable automation</b>	high investment in general purpose equipment	lower than fixed automation	flexibility to deal with variations and changes in product configuration	most suitable for batch production
<b>Flexible Automation</b>	high investment for a custom-engineered system	medium production rates	flexibility to deal with product design variations	continuous production of variable mixtures of products

Automation in the context of manufacturing often refers to the mechanization and integration of the sensing of environmental variables, which is done through data processing, communication of information, and decision-making. However, automation is applied in other contexts than manufacturing, focusing on the complex interaction between humans and technology, which combined is referred to as automation (Sheridan, 2002). In those other contexts, the complex interaction between humans and technology is focused on how humans use computers to interpret and record data, make decisions, and visualize the information. Recently, other definitions of human machine integrations have emerged that focus on the sharing of tasks between human and machines and that regard them as being complimentary (Satchell, 1998). Optimizing task allocation would give benefits because of complementarities of technology efficiency with the flexibility of humans. In the context of manufacturing, the systems would be more robust. Besides, task sharing is explained and applied at the operative level of manufacturing automation, and combined with a strategic intent the manufacturing automation can provide long term competitive advantages. Thus, manufacturing automation with strategic implications has become of special interest to both practitioners and researchers.

### 3.3.2. Motivation and consequences for automation

The motivation for automation can be viewed from different perspectives (Table 4), either from a company perspective or from the perspective of the production system designer, who pays special attention to human factors when automating. Groover (2008) pointed out nine reasons to justify automation in manufacturing, it is in the perspective of a company where productivity is in focus. Wickens et al. (2004) focus on the human factors view and listed four reasons for production system designers to automate in order to support or replace human work.

Table 4. Reasons for automating (Groover, 2001 and Wickens et al., 2004).

<b>Groover (2001) Company perspective</b>	<b>Wickens et al. (2004) Human factors perspective</b>
1 Increase labor productivity	Impossible or hazardous work for humans
2 Reduce labor cost	Difficult or unpleasant work for humans
3 Mitigate the effects of labor shortages	Extension of human capability
4 Reduce or eliminate routine manual or clerical tasks	Technical feasibility
5 Improve worker safety	
6 Improve product quality	
7 Reduce manufacturing lead time	
8 Accomplish processes that cannot be done manually	
9 Avoid the high cost of not automating	

In addition to the above classification, Zandin, 2001 commented that most businesses automate primarily to reduce costs and, thereby, improve their competitive position in

the market, yet, the real objective of this investment is to make money, not just save money. Diebold in (Einzig, 1957) also mentioned that the advantage of automation might well ultimately prove to be that it made management far more efficient, rather than that it economized on labour. Hence, the motivations for automated assembly should include other aspects in addition to cost savings as follow.

*i. Cost reductions*

Automation reduces labor costs (Groover, 2008), instead of direct labor cost, indirect labor costs (Aydan, 1989) can also be saved. As production requirements go up and labour costs increase, automation assembly becomes more attractive, in terms of direct labour cost reduction as a sound capital investment. (Riley, 1983) On the other hand, automation also contributes to the reduction in inventory cost. (Riley, 1983) The stock level is reduced in work in progress (WIP), finished goods and raw material inventory due to greater predictably of the production process, faster throughout times and due to the reduction of scrap and rework. (Aydan, 1989).

*ii. Quality improvement*

Automation can reduces scrap and rework (Aydan, 1989), thus the product quality can be improved (Groover, 2008). It also enhances the quality consistency (Zandin, 2001) as well as the quality with all of its warranty (Riley, 1983).

*iii. Shorter lead time*

As automation decreases production cycle times (Groover, 2008), it reduces product lead time and thus enhance faster response to market (Aydan, 1989). It may also give implications for suppliers such as being able of delivering just-in-time to a highly automated assembly line (Danilovic and Winroth, 2005).

*iv. Eliminate the threats of workers*

Riley (1983) pointed out many western countries face a declining rate of productivity, which has its fundamental root cause in changing attitudes of industrial workers. He said that the problem is either psychological or educational, as workers have a lack of motivation, a lack of patriotism, a lack of work ethic, or a different attitude toward the quantity of work done for a specific amount of compensation, workers in the main are not inclined to increase their personal productivity. In addition, strikes and issues raised by labour union are headache for many companies. It motivates company to automation in order to eliminate the threats of workers.

v. *Social responsibility*

Wickens et al. (2004) proposed one of the human factors to automation is unpleasant work for humans. It includes both the working environments and job tasks. Zandin (2001) said that automation can eliminate the hazardous during the manual operations for workers. Hence, the protection to the operator safety (Riley, 1983) is guaranteed. Considering semi-automation, as machinery can perform many complicated and repeating tasks, the remaining job tasks would be simpler for workers and less boring. It reduces certain human ethical issues such as child labour. Hence, the social responsibility of the company can be enhanced as providing better working conditions for workers is an important element.

*Consequences*

i. *Technical issues*

It is directly related to the reliability of automation. As according to Murphy Law: "What can go wrong will." The robots machinery have downtime, once it broken, it stop the whole production line. Since the maintenance and even replacement can be complicated and take a long time, the time break is longer compare to the production with manual labour. The cost of a strike in an automated firm will tend to be far higher: the stopping of work for any length of time may become disastrous with such ruinously expensive equipment (Einzig, 1957).

ii. *Economic*

Einzig (1957) proposed automated industries, because of initial installation costs and of the need to operate around the clock, cannot reduce output to meet falling demands. They must reduce prices in order to keep demand up. He contends that automation will help to reduce wide fluctuations in demands for capital because, unlike the past when entrepreneurs added or withdrew units of production facilities according to market conditions, automated facilities cannot be installed piecemeal or slowed down.

Robert (1957) commented it is logical but challenged that Dr. Einzig has not visited many modern plants. Automated facilities are going in piecemeal. Moreover, much production flexibility to meet changes in consumption is being achieved in some automated operations, particularly in small-parts machining.

iii. *Technological Unemployment*

As automation has a main purpose to reduce labor cost, workers are eliminated from the production line eventually. Technological unemployment is naturally resulted when machinery replace human works. Many jobs in the economy will ultimately be



automated via advancing technologies such as robotics and artificial intelligence resulting in substantial, permanent structural unemployment (Martin, 2009). It will change the pattern of working force and cause other social issues.

*iv. Quality issues*

Igor and Oliver (2008) mentioned that low automation can result in poor product quality due to reasons related to plant location, such as inadequate workers' skills and motivation etc. This is the most frequent problems mentioned and linked to human issues when managing the automated system (Wickens et al., 2004): attention problems, perception, and cognition. Most of these problems occur in the interface between technology and human. The consequence for the human being can be increased stress and workload (Endsley et al., 1997) and can therefore impact the whole system.

*v. Indirect Cost*

There are indirect costs regarding the implementation of new automation technology. Instead of saving in labor cost, Aydan (1989) pointed out that there are costs associated with automation technology. For examples the installation costs and running costs, including the hardware maintenance cost, software cost, training cost for operators etc.

*vi. Investment risk*

Implementation of new technology usually involve some degree of investment risk, automation also does (Riley, 1983). Since the automation technology involve a huge amount of investment, company will bear long term loans and influencing the cash flow. If there are problems occurs, the company will be suffer in financial difficulties and have risks to the running of the company as well.

### **3.3.3. Automation strategies**

*Automation as a manufacturing strategy*

Bolden et al. (1997) commented on Automation that even though it can be capable of supporting all three business objectives and introduced as part of a strategy with the single aim of either reducing costs, improving quality, or increasing responsiveness. It is still considered under organization-focused strategic emphases. Because it include more generic practices which are aimed at developing the capabilities of the organization as a whole, principally in relation to technology and employee development.

Lindström and Winroth (2010) said that the automation decisions are part of the decision area concerning the production process. Automation is traditionally treated rather superficially within the area of manufacturing strategy (e.g. Miltenburg, 2005,

Hill, 2000). To fully utilize the manufacturing potentials provided by automation, improvement and refinement of the automation decision on a strategic level is required. Among other decisions during the manufacturing strategy formulation, one question is to what degree different tasks should be automated (Slack et al., 2001). Heilala and Voho, (2001) proposed some principles and selection criteria for assembly automation based on flexibility, batch size, production volume and number of variants which show in Figure 7.

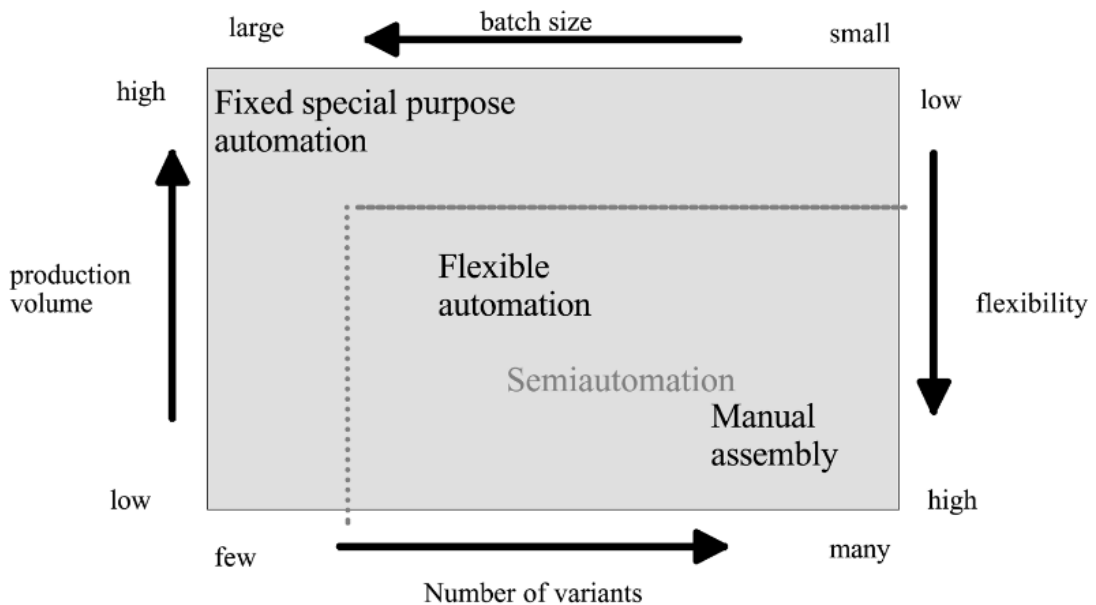


Figure 7. Assembly principle depends on many factors. (Heilala and Voho, (2001) modified from Rampersad (1994))

*“Righthomation” – Right-Automation*

The human factor and cost seems to be a key element in automation when considering its motivation and consequences. Human factor become the motivations for enhancing the working environment to the workers and it turn to a consequence that it increase worker’s stress and lead to employer elimination. On the other hand, automation seems to minimize the cost in production, but it can increase cost in certain situations such as poor quality. Therefore, as Igor and Oliver (2008) pointed out that fully automated assembly systems are not necessarily the best option in terms of cost, productivity and quality combined, which is attributed to high complexity product assembly system and therefore some de-automation is recommended. Thus, it is important to balance the level of automation according to the manufacturing objective. It should be a foundation in an automation strategy. A suggested framework ‘Righthomation: Right Automation’ by Säfsten et al. (2007) promote an appropriate level of automation, which is expected to have positive effects on the manufacturing performance as in Figure 8.

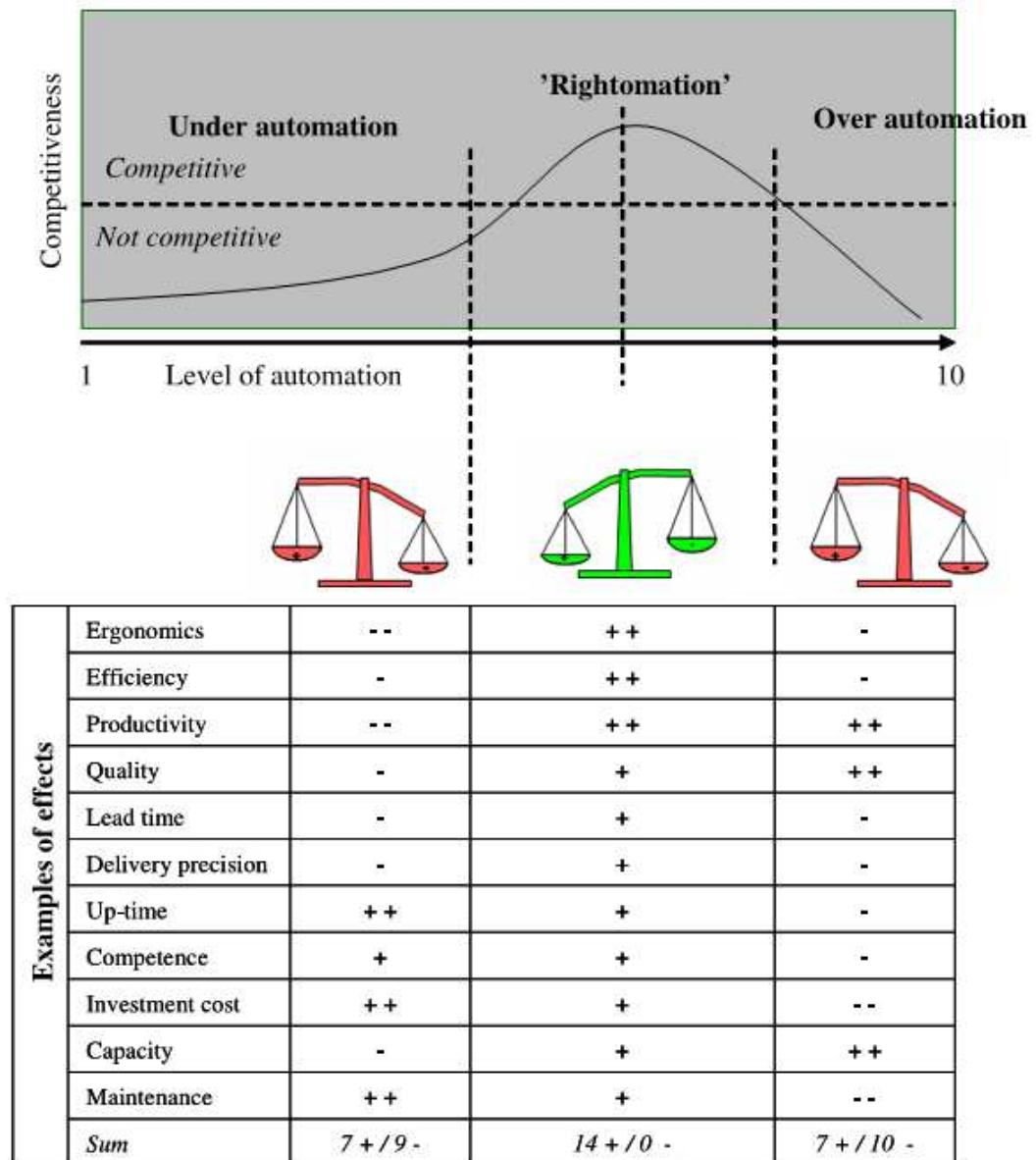


Figure 8. Appropriate level of automation, 'Righthomation'. (Säfssten et al., 2007)

In order to find the correct balance of automation and human work, it is necessary to analyse all the relevant aspects of manufacturing process, such as costs, quality, productivity and flexibility in relation to the local context. A more balanced combination of automated and manual assembly operations provides better utilization of equipment, reduces production costs and improves throughput.

#### *Automation Migration strategy*

Besides, the implementation of automation production should be a step by step process. Groover (2001) suggested the Automation Migration strategy, which is a formalized plan for evolving the manufacturing systems used to produce new products as demand grows. A typical automation migration strategy has 3 phases in Figure 9:

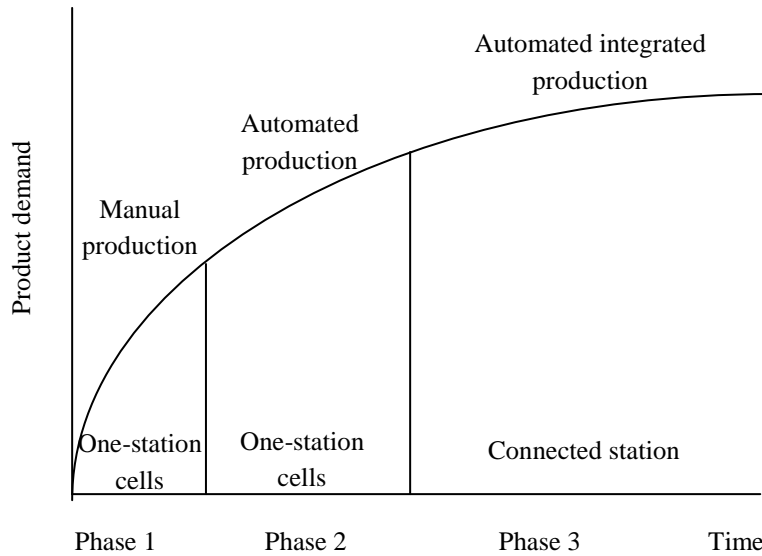


Figure 9. A typical automation migration strategy. (Groover, 2001)

Phase 1: *Manual production* using single station manned cells operating independently. This is used for introduction of the new product for reasons of quick and low cost tooling to get started.

Phase 2: *Automated production* using single station automated cells operating independently. As demand for the product grows, and it becomes clear that automation can be justified, then the single stations are automated to reduce labour and increase production rate. Work units are still moved between workstations manually.

Phase 3: *Automated integrated production* using a multi station automated system with serial operations and automated transfer of work units between stations. When the company is certain that the product will be produced in mass quantities and for several years, then integration of the single station automated cells is warranted to further reduce labour and increase production rate.

#### *First-Mover strategy*

As automation is enhanced by technology and innovation, therefore, the first mover strategy for technological innovation and implementation applies here. Lieberman and Montgomery (1988) discussed first mover as the pioneering firms in adopting new technology has the ability of to earn positive economic profits. First mover's advantages arise from three primary sources includes technological leadership, preemption of assets and buyer switching costs. However, there are disadvantages of first movers, which are in fact the advantages enjoyed by late-mover firms. Late movers may benefit from: the ability to 'free ride' on first-mover investments, resolution of technological and market uncertainty, technological discontinuities that provide 'gateways' for new entry, and

various types of 'incumbent inertia' that make it difficult for the incumbent to adapt to environmental change. Vulnerability of the first-mover is often enhanced by 'incumbent inertia'. Such inertia can have several root causes: the firm may be locked in to a specific set of fixed assets, the firm may be reluctant to cannibalize existing product lines, or the firm may become organizationally inflexible.

Lieberman and Montgomery (1988) added late-movers can gain an edge through resolution of market or technological uncertainty. The effects of uncertainty on the desirability of early versus late market entry. (Wernerfelt and Karnani, 1987) Entry in an uncertain market obviously involves a high degree of risk. They argue that early entry is more attractive when the firm can influence the way that uncertainty is resolved. After emergence of such a design, competition often shifts to price, thereby conveying greater advantage over firms possessing skills in low-cost manufacturing (Teece, 1986).

### **3.4 Synthesis of assembly industry**

Assembly applied to many different manufacturing industries, the common examples of assembly lines for consumer products include automotive, watch and clocks, garment, footwear, consumer electronic e.g. mobile phone, television etc.. Both outsourcing and automation have been carried out in these industries. To understand the synthesis behind, it can start with the overview of assembly operations.

Assembly operations are characterized by two basic categories: parts mating and parts joining. In parts mating two or more parts are brought together into contact or alignment to each other; parts joining means that after parts are mated, fastening is applied to hold them together (Nof et al., 1997). Assembly process also involves material handling, join, insert and fasten are common activities in assembly (Nof et al. 1997). The material variations can be an element to classify the assembly industry types. Saadat and Nan, (2002) mentioned flexible materials are used extensively in a wide range of industrial applications including the manufacture and assembly of garment and footwear products, the packaging industry and aircraft manufacturing. They mentioned these applications are often extremely labour intensive requiring fast and accurate manipulation of materials by skilled human operators and this has resulted in numerous international research and development efforts to automate certain handling and manipulation processes involving flexible materials.

The international research effort of automatic manipulation of flexible materials through a classification of work pieces in terms of their broad geometric shape, industrial applications, and individual processes has been examined by Saadat and Nan (2002). Their comprehensive survey of the international publication suggests that the majority of research effort has concentrated on applications with sheet materials, and of those, automatic manipulation of garment and fabric has received the highest attention. Figure

10 illustrate the industrial classification of automatic manipulation of flexible materials based on their shape geometry. (Saadat and Nan, 2002) It pointed out that garment manufacturing and automation is important to the research in industrial assembly.

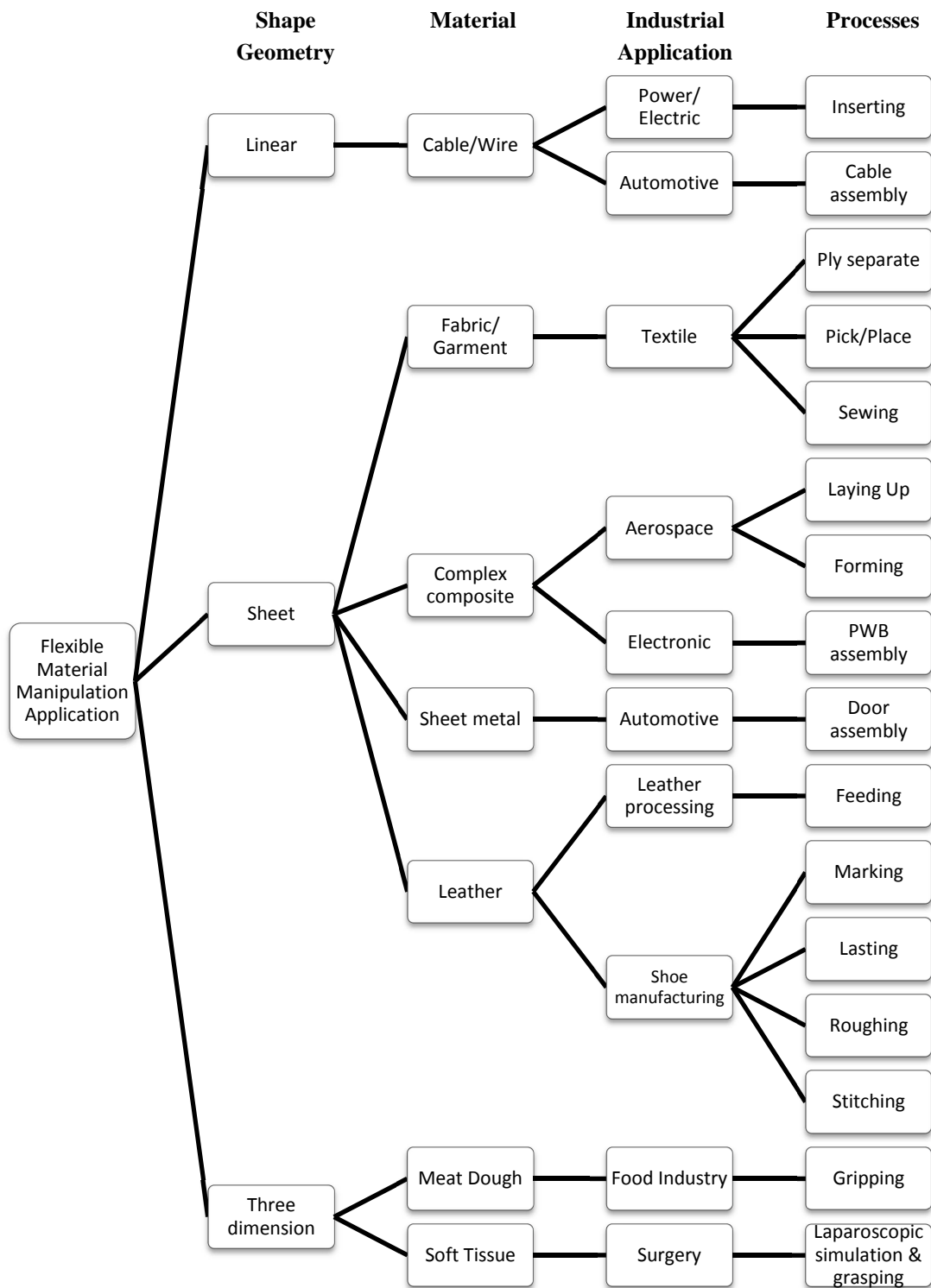


Figure 10. Industrial classification of automatic manipulation of flexible materials based on their shape. geometry. (Source from Saadat and Nan, 2002)

In addition, rationalization of assembly implies the efforts and investments to improve assembled products' quality and reduce their cost, it can be accomplished by a variety of engineering and management methods, automation is one of them. (Nof et al. 1997) The general area of assembly can be analyzed by its main distinguishing characteristics product complexity (number of parts per product), product turnover and industry type. The highest motivation for rationalization would be with assemblies that have a higher turnover and large annual production volume. (Nof et al. 1997) Hence, these variables are useful to analysis the synthesis in the assembly industry.

Likewise, the concept of commodity chain which distinct the product into buyer-driven and producer-driven (Gereffi, 1994) can be employed here for exploring the assembly industry as well. According to Gereffi (1994), buyer-driven commodity chains refers to those industries in which large retailers, brand-named merchandisers, and trading companies play the pivotal role in setting up decentralized production networks in a variety of exporting countries (typically in developing countries). This pattern of trade-led industrialization has become common in labour-intensive, consumer-goods industries such as garments, footwear, toys, consumer electronics, and housewares. (Céline, 2006)

On the other hand, producer-driven commodity chains are those in which large, usually transnational, corporations play the central role in coordinating production networks. This is a characteristic of capital- and technology-intensive commodities such as automobiles, aircraft, semiconductors and electrical machinery (Gereffi, 1994).

From the above identification, three common consumer product types in assembly industry including automation, mobile phone and garment, are selected for comparison based on the mentioned parameters: material type, product complexity and commodity chain in addition to the automation level in Table 5.

Table 5. Comparison of consumer product industries in terms of assembly manufacturing.

<b>Industry type</b>	<b>Automotive</b>	<b>Mobile phone</b>	<b>Garment</b>
<i>Automation level</i>	High	Moderate	Low
<i>Unit cost</i>	High	Medium	Low
<i>Annual Product volume</i>	Medium	High	High
<i>Product complexity</i>	High	Medium	Medium
<i>Material type</i>	Inflexible	Inflexible	Flexible
<i>Commodity Chain</i>	Producer-driven	Buyer-driven	Buyer-driven

The table show that, in addition to the lower unit cost, the flexible material type distinguished garment from other products. Yet, garment is special based on its material's characteristic which is highly flexible, it come to the same conclusion with the earlier findings that garment is difficult to automate (Taylor, 1993).



## **4. ANALYSIS IN GARMENT MANUFACTURING**

In this chapter 4, the objective is finding the trends in the garment industry. For instance, there is a big diversity between these two alternatives. Outsourcing has been practicing in the industry for many years, the challenges and problems are recognized already, therefore, the risk and threat are known. However, automation has not been carrying out and many consequences are still unknown. The problem may only be forecast but there may be unimaginable risk behind.

### **4.1. Trends in garment manufacturing assembly**

#### **4.1.1. The characteristic in garment manufacturing industry**

##### *Value chain of garment manufacturing*

Garment manufacturing is a process to make a garment. It is generally understood as cutting the fabrics and sewing them together. Yet, complete garment manufacturing process require a long period of time. The supply chain in the textile and clothing industry is relatively long with a number of parties involved (Jones, 2006).

Under the concept of Porter's (1985, 1990) value chain, it is a tool used to demonstrate the contribution made by each company activity to overall competitive advantage. Sturgeon (2000) defines a value chain as "the sequence of productive (i.e. value-added) activities leading to and supporting end-use". The clothing value chain is, as defined by Gereffi (1994), a buyer-driven commodity chain (Céline, 2006).

The value chain of garment industry can be divided into six stages of value adding activities to the final products. Starting from design and product development then following by sourcing and procurement. The raw material production including fibre, yarn and fabric could be before or after the first two stages, depending on the design requirement. Afterwards, the garment manufacturing starts with pattern making and cutting process and then carried forward for sewing and assembly process. The finished products go through the logistic and warehousing arrangement and then retailing for sale. The overview of the value chain in garment manufacturing is illustrated in Figure 11 as follow.

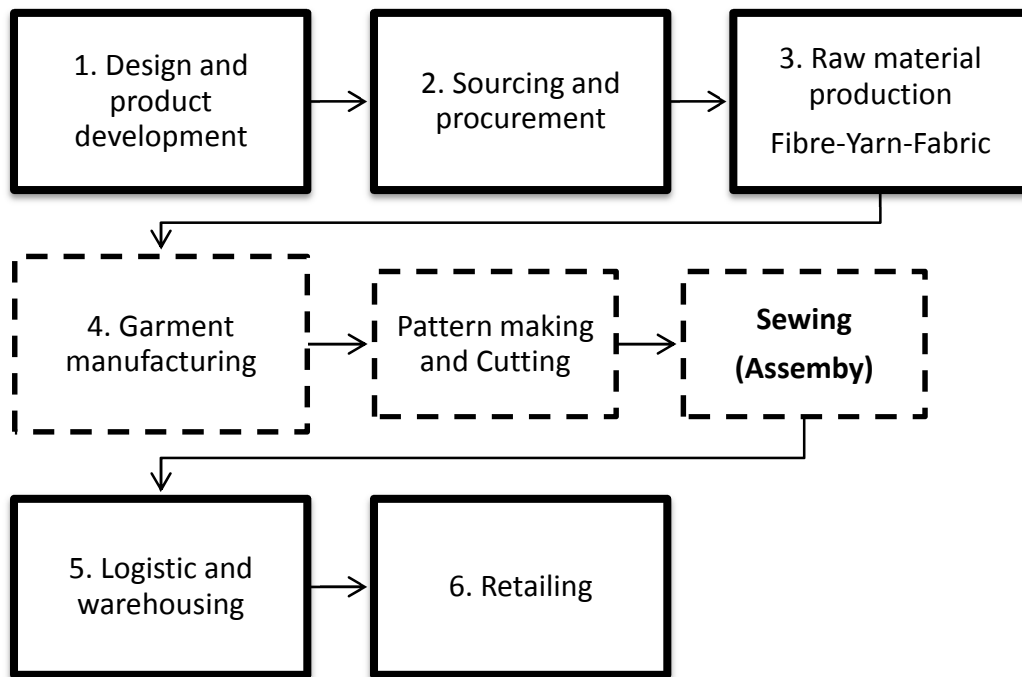


Figure 11. Overview of the value chain in garment manufacturing.

This is just a traditional pipeline to make a finished garment from raw material for mass production, in addition to the Starting from design to production and then retailing, they are all included in the textile and clothing industry, as how the whole supply chain goes. Hence, the textiles fabric manufacturer is the upstream supplier for the downstream customer, the garment manufacturer. This paper focuses on the garment manufacturing stage in particular to the sewing, assembly process.

#### *Large product categories*

Garment industry have a large range of product categories, the classification can be basically divided into men, women and children wear. Yet, more industrialized classification usually based on the fabric structure: knit and woven. Moreover, it can be also classified base on its functions, for example, sportswear, underwear, casual wear, suit, denim, evening dress etc.. As each of them required different assembly specification, thus, the level of complexity varies, therefore, the number of minutes per unit is different and the hourly labor cost is also different. Even they are in large variation, all these categories are within the garment manufacturing industry.

#### *Division of fashion and basic items*

In the industry, ‘clothing’, ‘garment’, ‘apparel’ and ‘fashion’ are interchangeably used in the literatures research. Abernathy et al. (1999) split garments into three categories: fashion, fashion-basic and basic. They defined fashion items as those garments with a

lifecycle of one season, fashion-basic garments are those that are a fashionable variation of a basic and basic, are those garments which remain in a collection for several years, e.g. a white T-shirt or classic black trousers. Hayes and Jones (2006) segmented the clothing market into fashion-conscious and non-fashion-conscious consumers. The term “fashion” has been defined as: a broad term that typically encompasses any product or market where there is an element of style that is likely to be short-lived (Christopher et al., 2004). Kunz and Garner (2007) added that apparel professionals often divided apparel products into fashion and basics items, as they have different product characteristics and lead to different business decision in marketplace. But Jones (2006) disagreed with the view that all garments can be at any one time be ‘fashionable’ and they are influenced to a greater or lesser degree by trends which have filtered down from the high fashion zones.

Even though, as a fashion product in the wearable garment form is still need to undergo the garment manufacturing process, the term ‘fashion’ is interchangeable with other terms in this situation. Yet, it is still important to clarify the differences of the concept of fashion and garment, as they have different requirement in lead time and responsiveness.

#### *Lead time, quick response and fast fashion*

Time control is very important in garment manufacturing in order to rush for the fast changing fashion trend with two major seasons in spring and fall every year. Traditional fashion retailers have relied on forecasting future trends instead of using real-time data to assess the needs and wants of the consumers, it has been suggested that this process can start some 18 months before a product is to be sold (Jackson, 2001). Therefore, the lead time in garment manufacturing has been extremely long.

Retailers such as Gap have an average lead-time of between three and nine months (Larenaudie, 2004), it is a regular speed in the fashion industry. But fast fashion companies such as Zara can operate on a lead-time of 15 days or less (Saini and Ryle, 2005; D'Andrea and Arnold, 2002), Mango and H&M have reduced their minimum lead-times down to approximately three weeks (White, 2004; Carruthers, 2003; Larenaudie, 2004). This short lead time competition is renowned with the term “quick response” which is viewed as a strategy used to achieve fast fashion (Hayes and Jones, 2006). It has been defined as a mode of operation in which a manufacturing or service industry strives to provide products or services to its customers in the precise quantities, varieties and within the time frames that those customers require (Kincade,1995).

A fast fashion strategy has a positive effect on stock turnover (Hayes and Jones, 2006). Quick response is also a critical factor in the process of improving competitiveness within the industry because, by making the entire chain directly dependent on market

expectations, it ensures that a better service is provided, stocks are reduced, and clearance sales caused by forecasting errors are eliminated (Richardson, 1996). Therefore, managing the supply chain to reduce the lead time and achieving quick response has always been a big challenge in fashion business. Agility or even 'leagile' approach is widely studied in the literatures (Bruce et al., 2004). Forza and Vinelli (2000) mentioned that the quick response practice can be emphasized into the fabric and garment design/production cycle and the supply, production and distribution cycle. Particularly the reduction of garment throughput times is in the interest of this study.

Indeed, Abernathy et al. (1999) claim that it is not essential to "rush" production for basic items because they are unlikely to go out of fashion quickly. They suggest that lead-time reduction is only relevant for fashion, and to some extent fashion-basic, products. Despite their claim, the market share of the non-fashion basic product could be captured by competitors beforehand if the products come too late.

#### *Sourcing services*

Sourcing activities can be based on the choice of supply market and supply channel. The global suppliers provide different sourcing and manufacturing services to the buyers. These suppliers or contractors are firms that take orders for apparel products from other firms and either produce or arrange for the production of those specific garments. The contractors are classified into two primary forms: CMT and full package, depending on the services level that they have provided. CMT (cut, make and trim) apparel contractors commonly provide apparel assembly services which include machines, labor and the thread to sew specified garments, the sourcing company provides product specifications and fabric. Full package contractors not only provide production expertise but also product development and materials sourcing. (Kunz and Garner, 2007) Furthermore, external sourcing can be divided into direct sourcing from manufacturers and indirect sourcing through agents or intermediaries (Popp, 2000).

#### **4.1.2. The global shifting in garment assembly**

Assembly is often the final process within manufacturing operations, being the final set of operations on the product, and being traditionally labour-intensive, assembly has been considerably affected by globalization. (Onori and Oliveira, 2010) According to Dicken's (2003) research on global shift, one of the most significant developments in the world economy over the last three or four decades has been shift in activity away from the older, developed economies towards the newer, developing countries, including the production activity. Inevitably, garment manufacturing which is traditional and large industry has been shifting from the old economies to the new as well.

It is a fact that many fashion companies from North America and Europe have subcontracted their production activities to other countries. These companies usually have the sourcing partners in different location regarding to their product types. They are usually the developing countries like China, Vietnam, Indonesia, Bangladesh or India, which are the sewing rooms of the world. (Walter et al., 2009) For EU, the clothing suppliers in the last three years is topped by China, follow with Turkey, Bangladesh, India and Tunisia as shown in Figure 12 (Euratex, 2011).

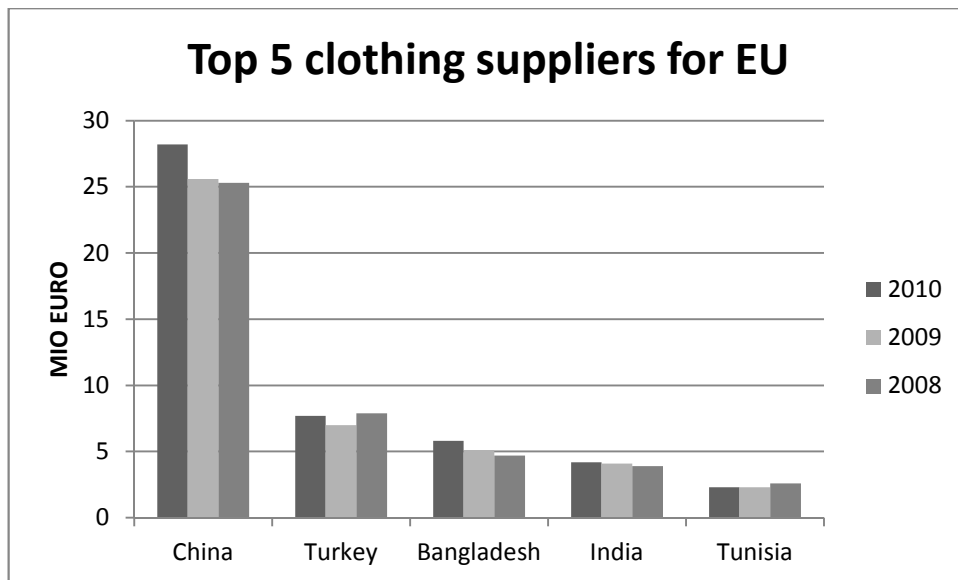


Figure 12. Top five clothing suppliers for EU in 2008-2010. (Euratex, 2011)

#### *Reasons for global shifting*

One of the major reasons for the shift is the high labour cost in developed countries, in which clothing production has moved to countries with lower labor costs. The move is because labor accounts for up to 50 per cent of the final cost of a garment (Lin et al., 2002). Figure 13 has shown the labour cost in apparel industry in 1990s. It shows that the labour costs in developed countries especially Europe and U.S. are much higher than the developing countries. This big difference started garment assembly outsourcing for production cost reduction. Jones (2006) mentioned that as the production of apparel has remained a labour-intensive operation, especially at the assembly (sewing) stage. Therefore, it follows logically that apparel production will be under particularly severe pressure to relocate to low-wage areas. Even though, there are also other financial reasons for many US apparel manufacturers to move their operations to different countries such as attractive tax policies. (Teng and Jaramillo, 2005)

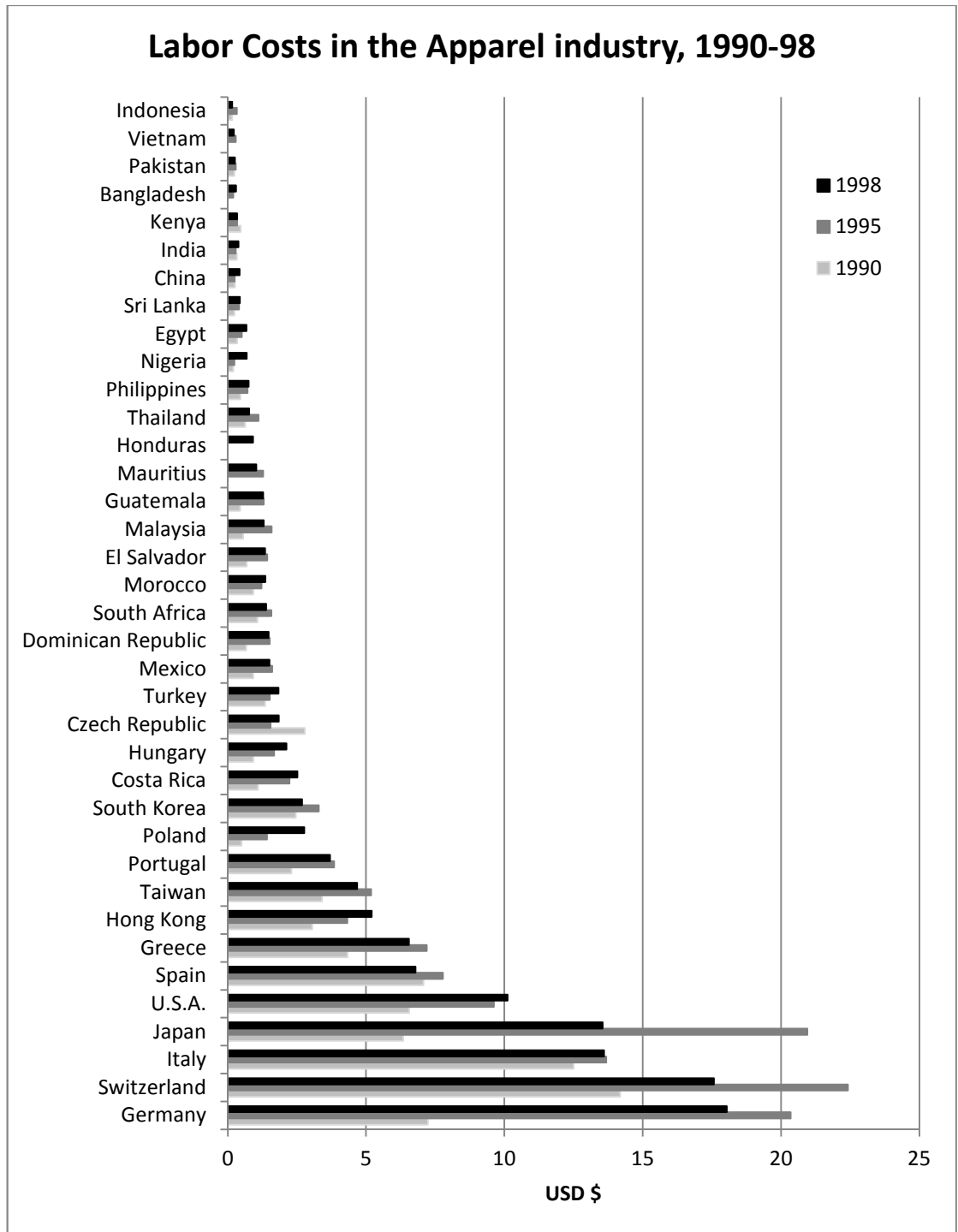


Figure 13. Labor Costs in the Apparel industry 1990-1998 in U.S. Dollars. (Source: Werner International, Inc, "Hourly Labor Costs in the Apparel Industry" (1998).)

Indeed, another reason behind the global shifting is in spite of large technological advances in engineering and electronics, the garment production is still extremely personnel dependent and therefore cost intensive. The traditional high-speed sewing machine – with manual manipulation of fabric by an operator – is with about 80% of the basic machine in garment production. The state-of-the-art automatic sewing units is

only available for 2D working steps such as buttonholer, bar tacker or pocket sewer represent only a part of 10 to 20% of current production lines. Therefore, the caravan of the sewing industry travels around the world from one low-wage country to the next. Walter et al. (2009)

#### 4.1.3. Technological development in garment assembly

In the textile and clothing industry, the first machinery, spin jenny had already been invented in the early decade, many other automated machineries such as weaving loom and sewing machines have been invented afterwards. In garment manufacturing, Rolstadas and Anderson (2000) clarified that automation can be employed in the pre-assembly, assembly and post-assembly stages. It can be broadly divided into soft and hard automation as well. The garment assembly process belong to the hard automation, Figure 14 (Chin et al., 2004) illustrated the classification of hard automation.

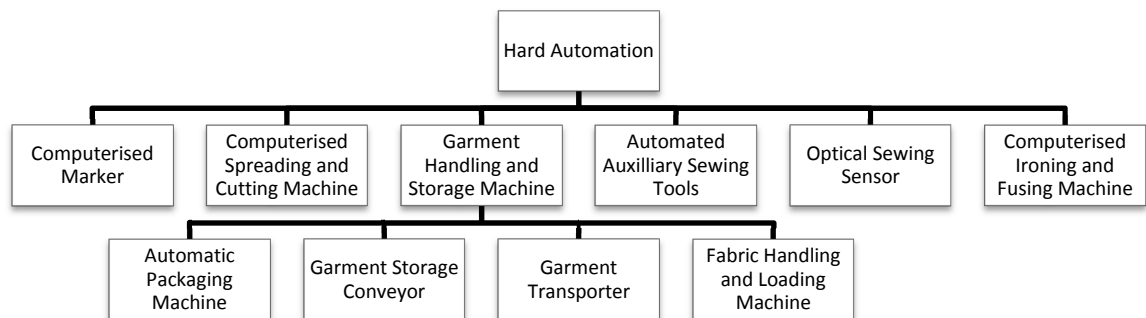


Figure 14. Classifications of hard automation in garment manufacturing. (Chin et al., 2004)

As from the figure, it is not surprised that many other stages in garment manufacturing has been automated. However, the following primary and secondary processes are very hard to automate because accurate and reliable fabric handling is an extremely difficult problem to solve (Cutkosky, 1985). In spite of that, many engineers and scientists have started the investigation in the development of garment assembly automation long ago in the end of nineteenth century. They have identified the major difficulties through numerous research and development.

In garment and textile industries, the contribution of costs associated with labour is significant, thus potentially providing maximum possible savings from the use of automation. There is, then, a need for a low-cost, highly reliable garment assembly system. The common, but critical and labour intensive components of fabric handling tasks are twofold: ply separation; and pick/place on pre-separated plies. (Saadat and Nan, 2002)

### *Difficulties in automation*

Material handling is difficult as fabric properties variation is high. Taylor (1993) mentioned the most important technical influence on automated garment assembly is the mechanical behavior of the fabric. There is a very wide range of fabrics used from fine silks and lace through to heavyweight denims. The fabric is a limp and soft material that does not have its own well-defined shape (Tait 1996). It made the grasp and handling operations are made difficult by the variability of the shapes, sizes, material composition, thickness and stiffness, the lack in available technology and systems for flexible handling of limp, synthetic and natural materials is one of the major bottlenecks to the extended robotization of the high human-labor-intensive sectors such as clothing and footwear manufacturing (Walter et al., 2009).

Second, it is important not to damage the material in handling. The material may be sensitive to temperature and humidity (Taylor, 1993), it can be also influenced by heat, moisture and pressure or stretch. Hence, a system that can handle different type of material and non-intrusive is needed. These material requirements has largely prevented the automation of the related manufacturing processes, even the robotic manipulation of rigid material is successfully realized and working in many industrial sectors. (Costo et al., 2002) That is why Taylor (1993) added people are extraordinarily good at coping with such uncertain and variable materials, automated machinery less so.

Another difficulty for garment assembly automation is the accuracy in the assembly process. The garment assembly process requires precision and forethought during the cut, transport and sewing operations (Tait 1996). Especially in sewing process, there are lots of associated handling: single pieces may need to be separated from stacks of cut panels, single pieces and subassemblies must be brought together and guided during the sewing operations and in more complex cases subassemblies must be folded or even turned inside-out. The stitching provides very high strength flexible joints difficult to achieve by other means. The sewing machinery itself may require adjustment (such as thread tension) according to the material being sewn.

Lastly, cost is the most difficult achievement for many innovations to obtain public acceptance. The robotic technology with lots of sensory feedback seems to be appropriate solution for garment assembly, but costly (Taylor, 1993). Even though the garment assembly automation technology is successfully developed, no manufacturer would like to invest in an unacceptable amount to replace the ordinary production.

Despite the difficulties, Kim and Johnson (2009) pointed out as labor costs increased in the USA, apparel production was outsourced to countries where labor costs were low (Reichard, 2000). At the same time, emphasis was placed on developing technology to reduce the costs of manufacturing. Numerous tasks involving manual labor were



replaced by microcomputer technology and robotics (Kalman, 1996; Reichard, 2000). If the trend toward mechanization continues, apparel production may become completely human-free in the future. Replacement of human labor in the production line could bring some apparel production back into the USA (Kim and Johnson, 2007).

According to survey from Kim and Johnson (2009) upon the future of apparel industry in USA in 10 -20 years, many participants envisioned further computerization and automation of production. Even though the main concerns are emphasized in information technology, but the technological advancement is still a hope for many participants. In fact, the development of automation technologies has been carrying out in different period:

#### *Japanese started in early age*

Starting from 1982, Japanese researchers had conducted the study of automation in garment manufacturing. Five types of garments includes tops, bottoms, dresses, sportswear and nightwear were studied. In February 1991 an experimental plant was demonstrated for the production of a ladies' blazer made from woven fabrics. It comprised a high speed laser cutting system, flexible sewing subsystem, high-tech assembly subsystem and three-dimensional flexible press subsystem. (Taylor, 1993)

With regard to the sewing operations, key technological achievements were:

- Sensory systems for checking the position, gripping and shape of fabrics.
- Automated bobbin replacement, exchange of needle thread, replacement of needle, machine setting.
- Fabric gripping technology-- "a mechanism that can grip fabric like a worker".
- Fabric conveyance technology.
- A 3D sewing system comprising a new lightweight sewing head carried on the end of a robot, as seen in Plates 1 and 2.

One noticeable feature of several sewing cells was the use of an anthropomorphic approach such as placing a sewing machine on a multi-axis robot or using two co-operating robots to move a subassembly under a sewing head as depicted. Clearly these techniques would be uneconomic, but there are many other more useful but less visible technologies which have been developed from this programme, albeit very expensively.

#### *European projects lately*

In the beginning of twenty-second century, the European textile and clothing industry carried out the Leapfrog project with a paradigm to enable automated 3D clothing assembly based on advanced robotics and innovative joining techniques. (Walter et al., 2009) This requires innovative fast and highly reconfigurable robotic resources in

handling and working with limp materials. An innovative concept for garment manufacturing comprises a holistic, general production-line from single-ply cutting, automatic transport to sewing processes with robotic 3D sewing and 2D sewing machines. They pointed out that robotic 3D assembly can improve quality, cost reduction and fast response to consumer market. Certain critical technologies are highlighted as followed:

- Robotic 3D sewing machine
- Adjustable 3D mould

The first part is the robotic 3D sewing technology and the adjustable 3D mould. The special robotic 3D sewing technology guided by an industrial robot makes it possible for the first time to sew 3D seams automatically. The idea comes from the welding robots in automobile production. Another important innovation is the development of an adjustable mould, which can adapt to different sizes and shapes for different garments.

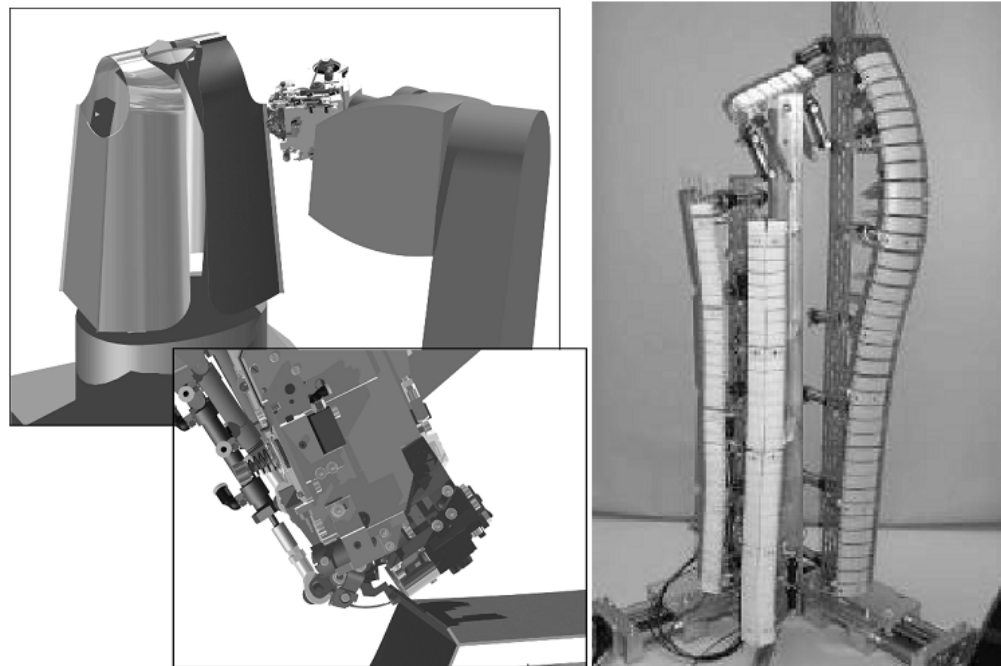


Figure 15. (Left) Basic principle: Robotic 3D sewing technology and spherically positioned fabric is assembled by robot guided sewing machine. (Right) The adjustable mould. (Philipp Moll GmbH & Co KG, Walter et al., 2009)

The second part is the robotic soft material handling which includes the following innovation:

- Automatic unloading cutting table
- Re-configurable multi-point gripper
- Re-configurable hanger

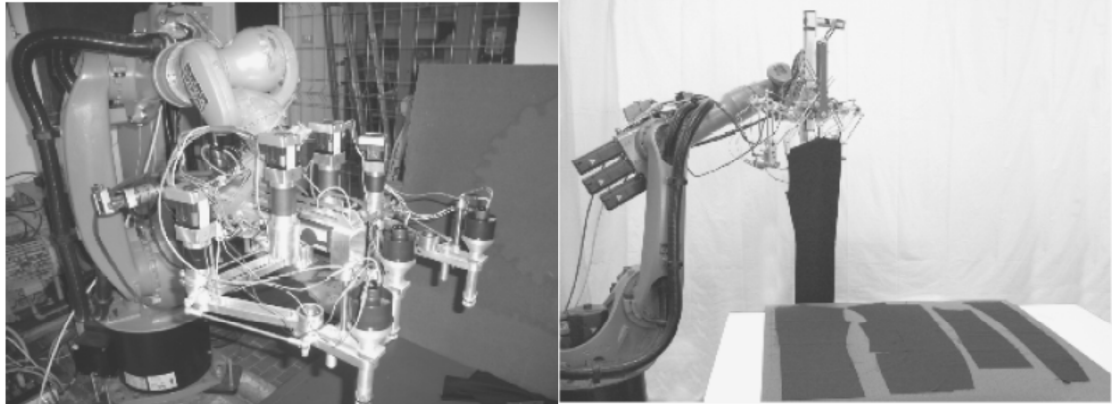


Figure 16. The grasping device prototype. (Walter et al., 2009)

Automatic unloading cutting table involves in all main handling issues: picking from flat, lifting up, displacing, releasing with required position accuracy. Also, the new concept of a re-configurable hanger that holds the individual fabric item during transportation to the following manufacturing stations is realized. Unloading of the cutting table and loading of the hanger are performed by a robot equipped with an innovative re-configurable gripper that picks and lifts up the cut part and transfers it to the hanger in one working cycle. The multi-point picking technology conceive an innovative grasping system and device architectures address the problem in handling of soft and limp materials with variability of the shapes, sizes, material composition, thickness and stiffness. (Walter et al., 2009)

Compare to the traditional manual style sewing machine, the 3D sewing system is a radical technology in garment assembly manufacturing, as it caused a dramatic change in the ways things are done (Ehite and Bruton, 2010).

## **4.2. Manufacturing strategies for garment assembly**

This section discussed the economics in garment manufacturing with the strategy of outsourcing and automation. In association with Skinner (1969)'s objective of manufacturing, cost, quality, delivery and flexibility are used as the foundation in the following analysis. These are the main criteria to judge the efficiency of these two strategies corresponding to assembly manufacturing in the future of garment industry.

### **4.2.1. Garment assembly outsourcing**

Yu and Lindsay (2011) suggested that international outsourcing generates both positive and negative effects on the firms' competencies in four manufacturing dimensions: cost, quality, flexibility and delivery. They also mentioned that there are problems arise in regard to flexibility and delivery, as well as quality control. The varying supplier performance in terms of price, quality, flexibility and lead times must be incorporated in

apparel firms' strategic sourcing decisions. (Åkesson et al., 2007) As discussed in Chapter 3.2.2, there are contradictions between the motivations and consequences of general manufacture assembly outsourcing, it occurs similarly in the garment industry. The driving force and problems are generally coinciding to the general manufacturing assembly outsourcing aspect. The discussion of outsourcing in the garment assembly aspect is whether to stay or quit.

### *Cost*

In the cost aspect, outsourcing production to low cost regions for cost reduction is a common practice in the clothing industry (Kumar and Arbi, 2008). Especially the cost of labour is high for many developed countries (refer to Figure 11), the garment manufacturing process moved to developing country. However, the hidden costs reduce the attractiveness of sourcing on the basis of low cost alone. (Christopher et al., 2004) Many outsourcing arrangements fail to deliver the expected cost savings, Juras (2008) argues that it is because management has not calculated the total cost of outsourcing, which implies the hidden cost behind. The dilemma of cost savings should make clear by computing the trade-off between low cost outsourcing and the associated hidden costs.

Yet, hidden costs of outsourcing can be avoided and mitigated by improving budget performance of outsourcing engagement. By predicting the likely hidden costs of outsourcing for each vendor under consideration, an informed choice can be made whether to outsource and choose the best vendor, based on the total cost picture. (Info-Tech Research Group, 2011). As hidden cost could be mitigated, cost increment is not a reason to quit outsourcing.

### *Quality*

Low cost outsourcing has always appointed guilty for poor quality, a company claimed in a research that Eastern Europe was not a feasible choice due to previous experience of poor quality production. (Bruce et al., 2004) Poor quality could be a reason to quit outsourcing. Yet, the lower quality level can be made with or without intention.

The intended lower quality level is a selection by a supplier with price focus sourcing strategy. Åkesson et al. (2007) said that it is a firm's characteristic towards product sourcing. Price is associated with the quality level, it is verified that as suppliers in China have the ability to make almost any type of textile and apparel product at any quality level at a competitive price (U.S. International Trade Commission, 2004). Cho and Kang (2001) claimed that finding suppliers who supply quality garments at a low cost named as the two-tailed quality-price, is another competitive focus of firms in the

apparel industry. Firms with a price focus apply totally reversed sourcing strategies than firm with a quality focus (Bolisani and Scarso, 1996; Bruce and Moger, 1999).

The unintended poor quality could come with bad suppliers selection and poor contractual management. In apparel firms' strategic sourcing decisions, it is known that that there are variations of supplier performance in terms of price, quality, flexibility and lead times. (Åkesson et al., 2007) The product quality is highly depends on the selection and management of suppliers and their subcontractors by the buyer. However, Gray et al. (2009) found that there is no negative association between firms' quality expectations and their propensity to outsourcing, and they explained this result by firms' overlooking on the quality issue while making outsourcing decisions. Yu and Lindsay (2011) argued that the initiation of international outsourcing may not necessarily be impeded by concerns about quality. Rather, firms may be concerned with addressing quality related problems in the 'post-outsourcing decision-making' stage of their production.

On the other hand, the negative impact of outsourcing on product quality can be mitigated by the effectiveness of contract enforcement. (Lu et al., 2009) They suggested that the product quality under outsourcing depends critically on the enforcement of contracts between suppliers and buyers. They find that outsourcing does lead to poor product quality, but the negative impact of outsourcing on product quality is mitigated by the effectiveness of contract enforcement. The presence of imperfect contract enforcement, namely, the court may make wrong rulings when there is a dispute on the component quality. Under these circumstances, the independent supplier under outsourcing has lower incentive to take precautions to ensure the component quality. However, the gap in component quality between outsourcing and vertical integration narrows as contract enforcement becomes more effective; and intuitively, the product quality gap completely disappears when contract enforcement is perfect. Therefore, the buyers need to carefully examine the effectiveness of contract enforcement among regions where their potential suppliers locate.

Quality is not by inspecting but making. It should be the original responsibility of the suppliers and sub-contractors. The initial selection of suppliers is the key to the quality level. Together with strong enforcement by effective contractual agreement, hence, poor quality is not a good excuse to quit outsourcing.

### *Delivery*

Efficient delivery is accompanied with fast responsiveness and short lead time in logistic. Turnaround time is critical for fashion retailers. European stores have created production models that deliver inexpensive fashion apparel in weeks, rather than months. (Dutta, 2002) Zara is a typical example which is an international fast fashion

company well known in selling its products quickly. The legend behind is despite the trend of outsourcing, Zara, makes and manufactures its designs in Spain (Dutta, 2002), and only outsources the production of clothing which is not subject to seasonal variation. They can thus operate with low working capital and boasts a significantly lower percentage of unsold items and enjoys higher net profits than its rivals.

Kumar and Arbi (2008) commented that outsourcing is not a viable solution for meeting short-term market demands. However, for large seasonal orders, outsourcing could be an enormous cost-saver. Cho and Kang (2001) as well as Alguire et al. (1994) also support that firms with high-product volumes are more suited for global sourcing strategies than those with small product volumes. Hence, even though there are arguments against outsourcing because of slow response, for the basic and seasonal items, outsourcing is still a winner.

In terms of distance, the supply chain could be shorter in outsourcing in expanding the companies' sales to global market. The reason behind is close to the market. Kumar et al. (2010) added outsourcing allow company to 'exploitation' or development of foreign markets (Dunning, 1993). But it is outside the scope in this study as the focus is to the sales market in Europe only.

In the current situation, companies adopting both near and remote offshore sourcing, which is the double sourcing strategy to minimize the cost and agility trade-off, for example, large quantity order is sourcing from China, and small quantity order is sourcing from southern Europe. The total costs for near offshore production is similar to the remote one when adding up with lower transportation cost, but it ensures the agility with shorter delivery distance.

The logistics challenge come from the longer distance suppliers. Even the cost in Asia far lower than elsewhere but the supply chain lead-time is longer (Kiley, 2006). The transportation cost is higher with large batch of orders come from the Far East. It is even higher cost when the air delivery is needed in urgent cases. The logistical challenges currently faced by the entire international apparel industry include multiple vendors and manufacturing locations and lack of process visibility (Pang, 2004).

Besides, due to the geographical and cultural differences, the communication to suppliers is more difficult. Despite of the modern telecommunication network, negotiations and meetings concern about physical products in garment type, in particular concerns about color, hand feel and quality are preferred in face-to-face format to obtain the real touch. Hence, the induced business trips and languages difficulties with suppliers add cost and workload to the buyers.

### *Flexibility*

Outsourcing may give flexibility to garment manufacturing as it has plenty options of suppliers for selection to produce different type of products and quality level. (U.S. International Trade Commission, 2004) For examples, H&M outsources its production from 700 suppliers of clothes, the flexibility of its production and low prices can be identified as the key factors behind H&M's success. (Lopez and Fan, 2009) Also, the outsourcing practice can allow capacity reservation to increase flexibility (Eppen and Iyer, 1997; Serel et al., 2000) when using distant low-cost suppliers.

However, outsourcing is inflexible when the buyer loss the control of the production. The buyers are geographically far away from the outsourced production site. Also, they do not have the right to control of the manufacturing process over third party properties in response to the resources allocation and production schedules. There are limitations to the flexibility under the contractual arrangement with the suppliers. (Lu et al., 2009) The difficulty to modify the manufacturing context under the formation of legal contracts made outsourcing inflexible. The negative consequences are prominent as once the hidden and inflexibility costs are quantified. (Lowson, 2001)

#### **4.2.2. Garment assembly automation**

Scheines (1993) argues the impacts of new technologies are the driving forces in transforming the apparel operations and business. It is true that even though there are many automated technologies have been developed in the garment manufacturing process, the garment assembly which is a critical procedure was not well developed. Therefore, it is a strong reason for driving the development of garment assembly automation. Walter et al. (2009) added that innovation is a reason for automation, as robotic 3D assembly offers very interesting possibilities and potentials for high-tech and high-quality garment manufacturing. The aim is to realize technologies for efficient manufacturing solutions that allow an improved quality, cost reduction and fast response to consumer market. Thus, garment assembly automation which is achieved with different kind of innovative technologies is not only for innovation, but also a strong force for business transformation.

The analysis of automation is different from outsourcing as a strategy for manufacturing assembly in the garment industry that the development of automation technology is still under construction. Therefore, the point of view is discussed on the future, it include the realization of the innovation and implementation of the new technologies.

### *Cost*

Walter et al. (2009) claimed that the new invented robotic 3D assembly can reduce cost for garment manufacturing, because the automation of sewing manufacturing allows

high productivity and efficiency independent of labour costs and manufacturing location. Riley (1983) mentioned implementation of new technology usually involve some degree of investment risk. Since the new technology investment could be expensive, it induces a sufficient burden of fixed cost to the operations of factory. Many owners will only look at the short term results and ignore the value in returns in long term. Even though, the initial startup cost for an automated system may be high, but the potential savings in work space, cycle time and an increase in production rate and overall quality can justify these expenses in the long term (Farhad, 2010).

Another cost issues are there are costs associated with automation technology (Aydan, 1989). In addition to the maintenance cost, software updating cost and training cost of operators, the system break down cost should be estimated as well. All these added to the variable and overhead cost on top of the total cost.

### *Quality*

The introduction of automation into the different phases of garment manufacture can improve quality (Hoffman and Rush, 1988; Aldrich, 1992). Walter et al. (2009) proposed quality is a reason for automation. They mentioned the most common sewing quality problems like seam puckering, layer displacements or problems with product fit, are a direct result of inbuilt weaknesses and process engineering of the traditional sewing machine and applied current sewing technology. Additional manual influence and the individual skills of the sewing operator substantially characterize the product quality. A further problem which is the most sewing operators in low-wage production countries are semi-skilled workers without professional training. Thus, replacing manual work by automated machinery can eliminate the errors caused by human as high level of automation can removal of human errors (Walter et al., 2009) However, machinery can also induce errors. Technical mistakes, in addition to the interaction between human and machinery can cause error too.

### *Delivery*

It is not doubt that machinery can perform task faster than human. Therefore, it can of course shorten the lead time. It is also commented that the introduction of automation into the different phases of garment manufacture can offer an instrument for obtaining further compression of lead times (Hoffman and Rush, 1988; Aldrich, 1992). As automation has the benefit in reducing manufacturing lead time, it enhances fast responsiveness of fashion product to the market. In addition, Walter et al. (2009) added the automation allows labor-cost-independent production thus independent of manufacturing location, production can be nearer to end-use markets with short response time automation.



### *Flexibility*

The new concept of garment manufacturing by Walter et al. (2009) has attempted to exploit flexible automation for garment assembly. This new type of manufacturing systems will allow flexibility not only in producing a variety of parts, but also in changing the system itself. Such a system will be created using basic process modules – hardware and software – that will allow quick and reliable re-configurability to adapt to new production needs (Walter et al., 2009). Even though, this is still just a conceptual projection, the justification has to be based on the actual result after the realization of garment assembly automation.

### **4.3. Comparison between outsourcing and automation**

There are different or similar motivations for outsourcing and automation, as well as associating consequences. Both outsourcing and automation have the ability to achieve the manufacturing goals. In response to the characteristics of fashion/garment manufacturing industry, there are certain important criteria that form the basis to compete in the global market. Table 6 shows the comparison of automation and outsourcing regarding the differences. The cost, quality, delivery and flexibility as the key criteria are discussed.

Table 6. Comparison of Automation and Outsourcing.

	<i>Automation</i>	<i>Outsourcing</i>
Labour cost	eliminated	transfer to outsider
Indirect cost/Hidden cost	maintenance, upgrading	transportation, other cost
Quality	better or worse	better or worse
Delivery	faster	slower
Flexibility	flexible automation, limit to the functions of machinery	plenty of options but limit to the suppliers
Investment risk	automation technology	foreign suppliers

### *Cost*

In the cost related issues, cost reduction is the major discussion point. Both outsourcing and automation have the credibility to save production cost, especially in labor cost.

Yet, outsourcing often bares the hidden cost problem and increase the total cost in the end, which make outsourcing unfavorable. On the other hand, Automation needs investment in the new automation technology, it bare fixed cost in machinery and may induce indirect cost in operation and the initial investment could be expensive for many companies. Thus, the decision is which of the strategy require lower cost and provide higher saving in the long term.

### *Quality*

Regarding the quality issues, since outsourcing to an outside supplier meaning loss of control in production, it has raise problem in bad quality products, yet there are also good quality products from better suppliers. Therefore, the selection and monitor of suppliers as well the maintenance of contract enforcement is critical for the quality level. On the other hand, Automation allows the control in production and reduce human related quality problem. However, there are still possibility to affect the product quality, especially in the situation of human operators and machinery interaction.

### *Delivery*

In the fashion industry, as fast response and short lead time are critical to success, hence, the responsiveness achieved by shorter lead time is one of the important measurements in manufacturing. As the supply chain can be divided into production and distribution phases (Forza and Vinelli, 2000), these two phases can be employed to the comparison of lead time.

For the production lead time, as machinery is expected to be faster than human, Automation is for sure having shorter production lead time than outsourcing to low cost labour countries. As compare to a labour factory, machinery is of course possible to work 24 hours a day without resting, but the correlated overhead cost such as electricity would be higher. However, in the fair comparison, it has to be compare under the same value of cost correspondence, which is the total value of machinery compare to the outsourced product cost. Regarding the distribution lead time, outsourcing to low cost country bear long lead time and thus slower response to the market. It is because the suppliers are located remotely in the Far East for the westerns buyers, the long distance delivery increase the lead time sufficiently. On the other hand, Automation have no restriction in location, the factory can be located near the point of sales. Hence, the shorter distance reduces the lead time for transportation. Yet, it is only the point of view in the western market, the global market is not considered in this situation.

### *Flexibility*

Garment assembly by automation may have high manufacturing flexibility in terms of flexible automation. However, it is limited to the functional development of the

automation machinery. On the other hand, outsourcing has plenty of options towards the product variety, volume, quality level, time and price. Yet, once the contractual arrangement is made, they lose the control of the manufacturing as the manufacturing process is under supervision by the suppliers.

In addition to the arguments on the four manufacturing objectives, automation was found not to be suitable in certain circumstances, Groover (2001) projected there are a number of situations where manual labour is to prefer:

- when items are technically too complicated to assemble or manufacture with the help of a machine
- when the product life cycle is short and a fast market introduction is required
- for customized products
- when the demand is fluctuating

The above four situations exist in the garment product concurrently. In the first case, it has been discussed that the garments are technically very complicated to assemble because of material handlings and accuracy. Second, in the fashion world a fashion garment has a relatively short product life cycle, since fashion trends change every season and hence the products need to be delivered fast enough to the market before the trend has gone. Third, due to the individualism of consumer, customization is important in the fashion market, mass customization is practiced for achieving product differentiations. Fourth, the demand of fashion products are unpredictable to a large extent as the degree of acceptance to different designs and styles varies person to person, therefore, the production line flexibility is critical in order to avoid excess stocks.

It seems that the fashion products are not suitable for automation. Groover (2001) has not mentioned what is the reason behind the un-favourableness. Yet, as mentioned earlier, the garment product can be divided into fashion and basic items. Therefore, except the first case, the other three cases are applied to the fashion items only. The basic items garment seems still suitable for the automation process.

As fully automated assembly systems are not necessarily the best option (Igor and Oliver, 2008), the key point should not be focus on either fully automation or fully manual, it should be a balancing between manual work and automation. The transformation process should also be taken step by step, depending on the products complication and material used.

## 5. FUTURE SCENARIOS: THE SELECTION OF ALTERNATIVE STRATEGIES

This chapter presents the future of garment assembly manufacturing in scenario approach. It is the most important part of the study, by investigating the trend and events from the previous chapters; the uncertainties are figure out for the development of future scenarios. The scenarios planning are associated with strategies as recommendation for the industry in the future. The effort of scenario development and scenario planning is generated by own knowledge and creativity as a tool towards the future of garment manufacturing industry.

### 5.1. Uncertain variables for future garment assembly

Walter et al. (2009) proclaimed that automation of sewing process is needed to cease outsourcing and it is the only way to stop the further migration of garment manufacturing and associated machine building away from Western and Southern Europe. Disregarding the unavailable of automation technology, both outsourcing and automation are in fact caused by high labour cost for garment assembly in Europe. If the labour cost is also high in the rest of the world, the assembly process would remain in Europe. Hence, the arguments between automation and outsourcing are actually triggered by both labour and technology. Therefore, the availability of labour and technology are the critical uncertainties, their relationship creates the room for further discussion and are going to be discussed as follow.

#### *Availability of Labour*

The availability of labour can be divided into two aspects. As traditional garment assembly required a large amount of manual labour work, therefore, the plenty of labour supply with skills and technique is the first aspect. On the other hand, the labour cost level is important as cost reduction is a goal in manufacturing.

#### *i. Skilled labour supply*

The supply of labour is a critical issue in assembly manufacturing because garment sewing is highly labour incentive. Europe is entering an age of decreasing labour forces and new member states, even these new member states will denote positive birth rates and larger labour forces, all the while maintaining lower wages in the short term, European population levels will never double. (Onori and Oliveira, 2010) Thus moving

back all the assembly work to Europe is not so possible to supply such a huge batch of orders every season. The hope is denoted from higher population nations. In Asia, China and India dominate the top two highest populations in the world, which secure tremendous supply of labour currently. Even though slow population growth rate resulted from the introduction of 'One Child Policy' in China, it will still be the country with the highest population until 2025 when India overtakes China. (United Nations, 2006)

Nevertheless, the sewing process requires not only high population of labour, but also skillful workers. The decline of population, the less willingness of future generation to enter the industry and lack of knowledge transfer to the next generation would inhibit the future of garment assembly manually.

*ii. Labour cost*

The labour cost reduction is the major driving force for garment assembly outsourcing, as well for automation. It is critical to many companies' decision upon whether to outsource or not, or where to outsource. Therefore, the labour cost level is a key factor but it is not so certain in the future.

It has already known from Figure 11 that low labour cost countries are the major attraction for outsourcing. However, the labour cost can be either rising, falling or remain unchanged. If the labour cost in the low cost countries increase, companies need to recalculate their cost of outsourcing, and decide where would be the reasonable production site. In extreme case, when the labour cost growth subsequently and achieved as high as the level in the industrialized countries, outsourcing is not a reasonable strategy anymore. In this situation, the automation seems to be possible alternative. Even though no one can forecast the labour cost level in the future, signs can be observe through the trend from historical statistics. The following figures show the variations of labour compensation cost in the apparel industry in 2000s.

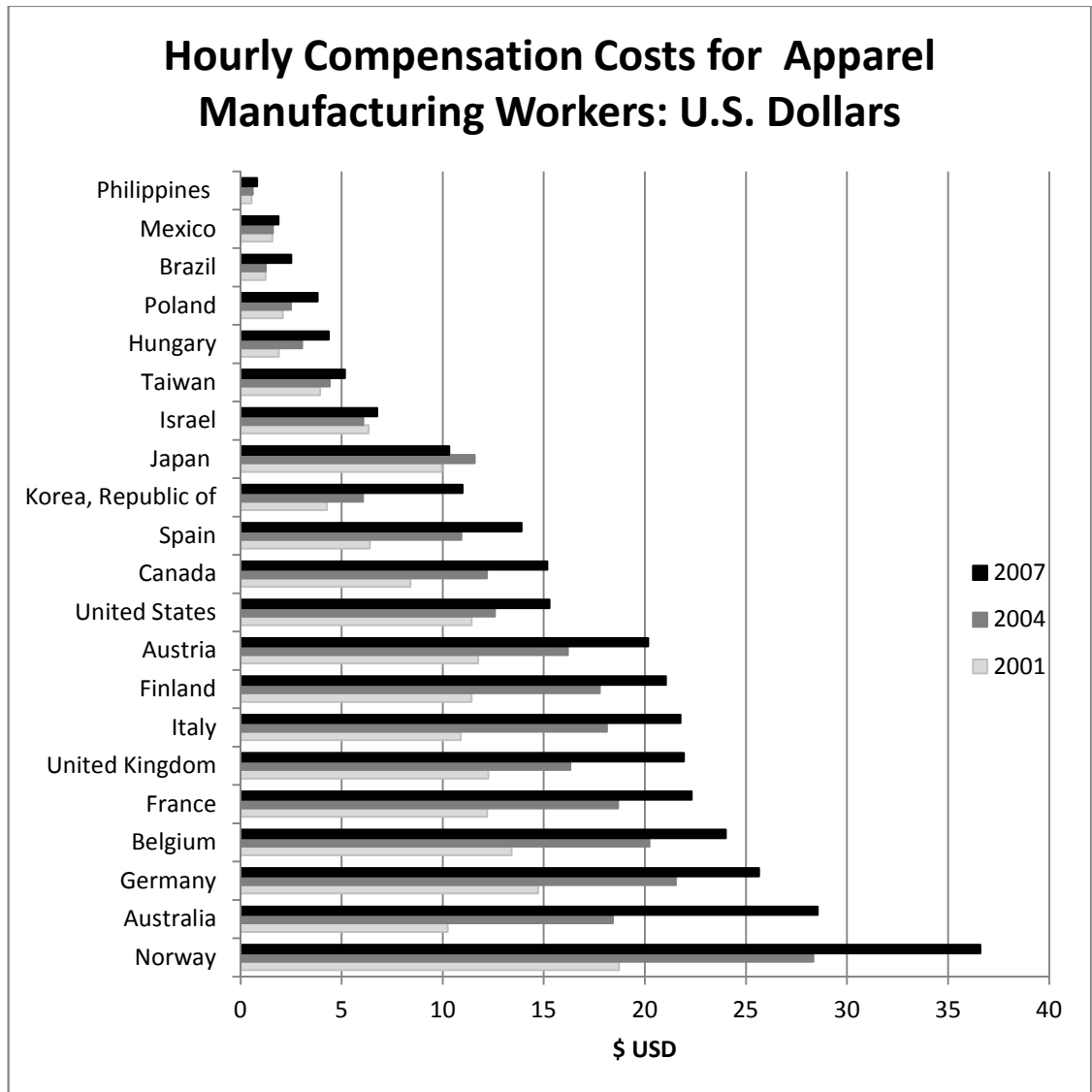


Figure 17. The hourly compensation costs for apparel manufacturing 2001-2007 in U.S. dollars. (U.S. Bureau of Labor Statistics, 2011)

According to the statistic from U.S. Bureau of labour statistics (2011) on Figure 17, it is shown that there are still big differences of labour cost from developed countries and developing countries. There seems to be the trend in the industry that the labour costs are raising concurrently, except the drops occurred in Japan and Israel in 2007 and 2004 respectively. Even though, the above figure show the labour costs mainly in developed countries, it is not sufficient to represent the majority suppliers recently on behalf of outsourcing. Another statistic from Jassin-O'Rourke Group in 2002 and 2008 show the comparison of the apparel manufacturing hourly labour cost in Figure 18 bring out more implications to the major developing nations, the low cost suppliers.

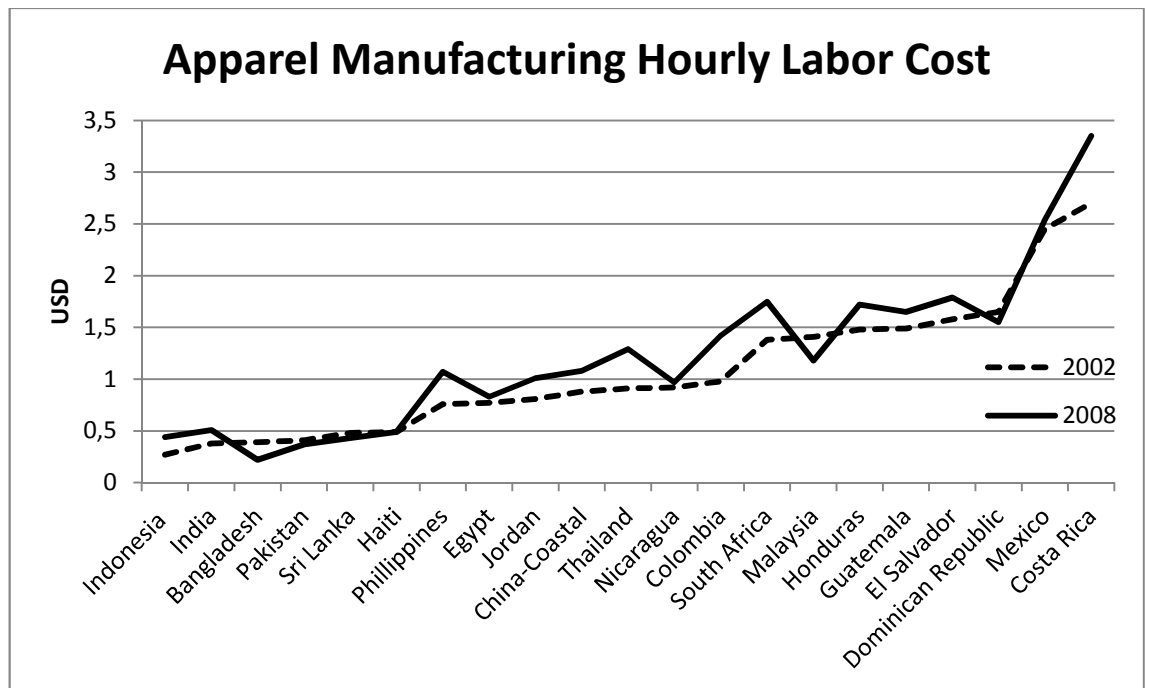


Figure 18. The apparel manufacturing hourly labour cost in 2002 and 2008 from selected countries. Currency in USD, include all benefits and/or social charges. (Source: Jassin-O'Rourke Group 2002 from Abernathy et al. 2006 and Emerging Textiles 2008.)

From Figure 18, it is able to observe that the labour costs of most countries are increased, especially for the major EU suppliers China and India. The operating cost of China's garment manufacturing industry is increasing rapidly due to the strict product quality requirement, increasing unit labor cost and harsh regulations on labor right and working hours. (Ngai et al., 2009) Similar reasons may apply to other countries. In addition, there may be very large differences in labor costs within a country as minimum wages may vary depending on economic zones, for example labor costs in China's inland are difference from coastal provinces (Emerging Textiles, 2008). Figure 18 only show the richer coastal area for comparison due to limitation of inland data.

Conversely, some countries such as Bangladesh and Pakistan have lower labour costs than before. The US dollar conversion strongly affects the results but makes sense as international prices are set in US dollars (Emerging Textiles, 2008). Other reasons behind need further investigations. Anyhow, the most important message from the figure is that the movement of labour costs in the future is unclear.

In the economic theory, the supply of labour is directly affected to the labour cost. The more the labour supply, the lower the labour cost. Similarly, the labour cost, in other words, the wages, also influencing the labour supply. Concerning the hygiene factor only, the higher compensation for the labour, the more labour force will be. Also,

manufacturer can pay higher wages to attract the workers to work during the period of low labour supply. These two labour factors are interrelated as expressed in Figure 19.

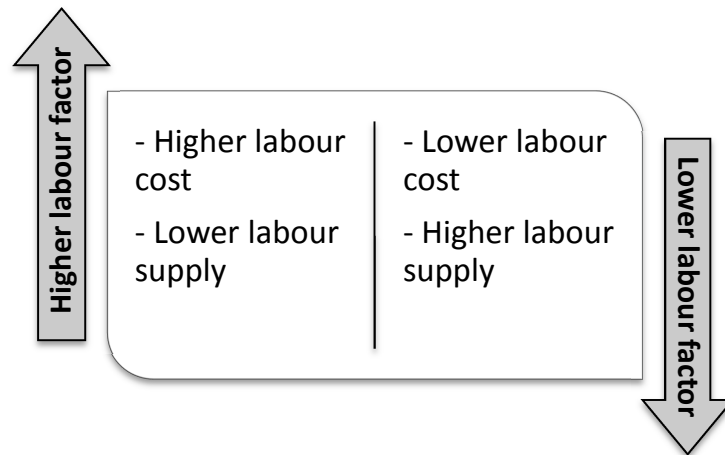


Figure 19. Labour factors relationships.

Labour factor proposition: *when the labour cost is high and labour supply is low in the low cost countries, the higher motivation for the company to shift away from outsourcing, outsourcing is less favourable than automation.*

#### *Availability of technologies*

Concerning the automation technologies for garment assembly, even the major basic technical bottlenecks were successfully overcome in the innovative fabric handling, joining and garment assembly processes, but more component development, overall system engineering and extensive industrial testing work will be required before commercial exploitation and industrial implementation at a significant scale can occur (Walter et al., 2009). Therefore, there are not any testing data and results for the innovated technology yet. The curious towards whether the development of automation can be used in mass production in terms of cost and feasibility is completely uncertain.

Nof et al. (1997) used several measures to assess the performance and cost-effectiveness of alternative assembly designs and decision, these effectiveness measures includes: assembly throughput, assembly capacity, assembly lead-time, in-process inventory, availability, flexibility, quality and cost per assembly. Vos (2001) suggested the most feasible type of assembly for a given situation depends on several parameters. The most important ones are production volume (the number of products to be assembled per time unit) and product complexity (includes the number of parts per product and the number of different product types). These would be the parameters for the future technological testing data. For instance, the level of these parameters could be corresponding to the three different type of automation production system: fixed, flexible and programmable



as mentioned in Chapter 3.3.1. The acceptability of the automation technology is accomplished with the cost and the functional performances. The technology is welcome with high performance and reasonable cost level.

The proposition here is: *when the cost of the technology is low and the functional performance is high, the higher the acceptability of the automation technology.*

## **5.2. Future scenarios development**

The change in uncertainties directly affected the realization of scenarios. The interrelationships of labour and technological factors are key variables direct the future into different scenarios. The following two variables are considered in correlation to the scenarios and thus generated the four scenarios in Figure 20:

- Labour factor variables: *when the labour cost is high and labour supply is low in the low cost countries, outsourcing is less favourable than automation.* Labour factor consists of labour cost and labour supply, labour factor increase while higher labour cost and less labour supply, labour factor decrease while labour cost is lower and labour supply is more. The labour factors here refer to the potential outsourcing nations.
- Technological factor variables: *when the cost of the technology is low and the functional performance is high, the higher the acceptability of the automation technology.* Technological factor consists of the functional performance and the cost of automation technology. Technological factor increase while functional performance is higher and cost of automation is lower. It decreases with lower functional performance and higher cost of automation.

*Note: The weighting of the individual parameters is not assigned.*

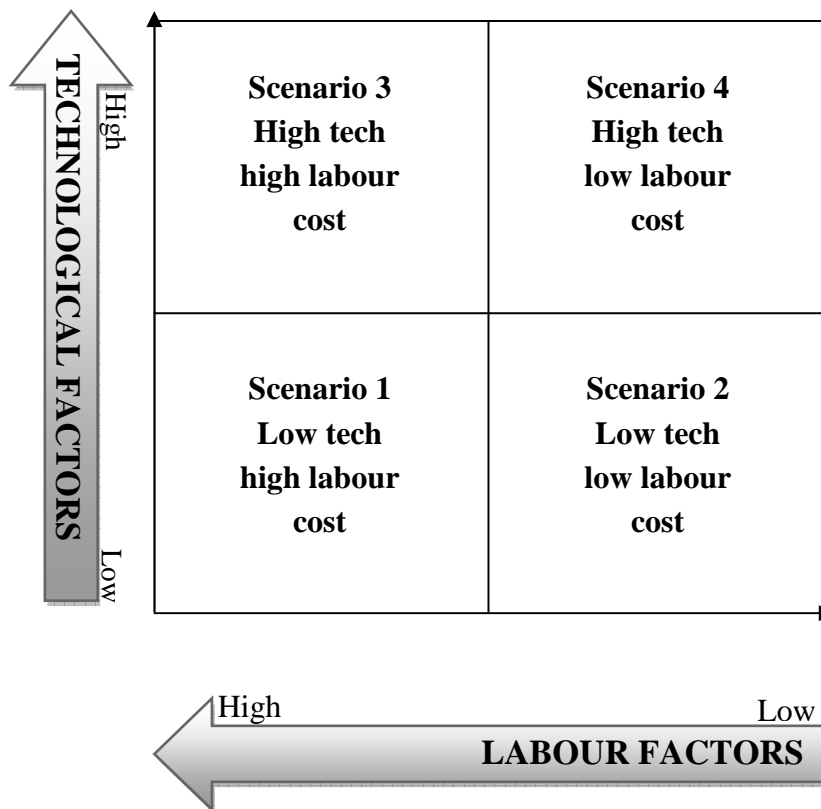


Figure 20. Future scenario associated with uncertain variables.

In scenario 1, the labour factor is high which means the labour cost is high and the labour supply is low, outsourcing is not favorable. At the same time, the technological factor is low which implies the functional performance of the automation technology is not high enough for mass production and the cost is high as well, automation is not a worthy decision. Hence, both labour and technological factors keep outsourcing and automation away from the industry, other solution has to be developed. The future of the entire global fashion industry resembles the recent garment manufacturing industry in Western Europe and North America with high labour cost and not at all technology available to garment assembly automation.

In scenario 2, with low labour factor, the labour cost in the low cost countries is still lower and there is a plenty of labour supply, outsourcing is still a favorable selection. On the other hand, with low technological factor, the cost of automation is high and the functional performance is not practical. Hence, outsourcing remains as the favorable practice in the industry. It is exactly the same situation as the current garment manufacturing industry in developing countries, i.e. low cost countries where low cost labour available for manufacturing practices wisely and not at all automation technology available for garment assembly.

In scenario 3, the labour factor is high, the labour cost is high and the labour supply is low in the entire global fashion industry, outsourcing is not anymore a feasible solution for manufacturing. Despite the unfortunate, with high technological factor, the functional performance of automation technology is achievable for mass production and the cost of the technology is not so high. Automation become the substitute of outsourcing and dominates in the industry. Similar situation in the automotive industry in Japan and Germany, where the labour cost is high and the automation technology is widely adopted.

In scenario 4, as low labour factor means labour cost is not as high as in the developed country and labour supply is sufficient, outsourcing is still an option for labour incentive manufacturing. Concurrently, high technological factor offer feasible functional performance of automation technology for industrial production and with reasonable investment cost, which makes automation attractive. Hence, both outsourcing and automation could exist together to serve the industry.

Certainly, the four scenarios are only the distinct situation with different combination of the uncertainties in labour and technological factors. The reality would be so different that the in between scenarios condition could happened. Particularly, the uncertainties value are not going to be described as high or low but rather in measurable value. Thus, the intermediate values between high and low will exist. For example, regarding technological factors, when the cost of automation technology and the functional performance are both high, the factor is thus in the middle but not high or low. These create much more complex dimensions and computerized calculations should be adopted to simulate different situation.

Furthermore, the weighting of each parameters in the factors are not assigned, which means the importance of them are not determined here. But in reality, some company may be more cost conscious and some are more performance conscious. Even though, the labour factor cannot be influenced by the individual, and they are interrelated to the demand and supply theory, thus, it is out of the control and considerations in this case.

### **5.3. Strategies for scenarios**

#### **5.3.1. Strategies recommended for individual scenarios**

The four scenarios only show the possible situations associated with the uncertainties in labour and technological factor. It is only the first step to explore the future of garment assembly manufacturing industry. To maximize the values of scenarios, alternative solutions should be prepared for future planning. No matter which scenario is realized, company need to decide whether to cope with the new changes or walk against the major trend. Concerning the decisions in manufacturing strategies, managers have to

face the questions like whether they should continue in outsourcing or invest in automation. Basically, there are only four selections for the decision:

1. focus on automation, giving up outsourcing
2. keeping focus on outsourcing and neglect the automation
3. selecting both outsourcing and automation strategies
4. selecting none of them

The first two options are choosing either one of the alternative strategies. In contrast, the third and fourth options are either the combination strategies, or none of them. These selections induce different results in different scenarios.

In the first option, when outsourcing is giving up, manager would need to know how much or to what level of automation should be invested. In the second option, when outsourcing is still considered, how to solve the problem come with outsourcing. In the third options, there are much more decisions behind as both outsourcing and automation involved together. In the fourth option, when neither automation nor outsourcing is involved, a third strategy is implied.

The objective of this study is to investigate the two strategies for manufacturing, automation and outsourcing, which one is more promising for garment assembly in the future. In accomplish with the fundamental decisions, the two alternatives of manufacturing strategies are revised and assigned into the scenarios. The four strategies associated with the future scenarios for the future garment assembly manufacturing is shown in Figure 21 below.

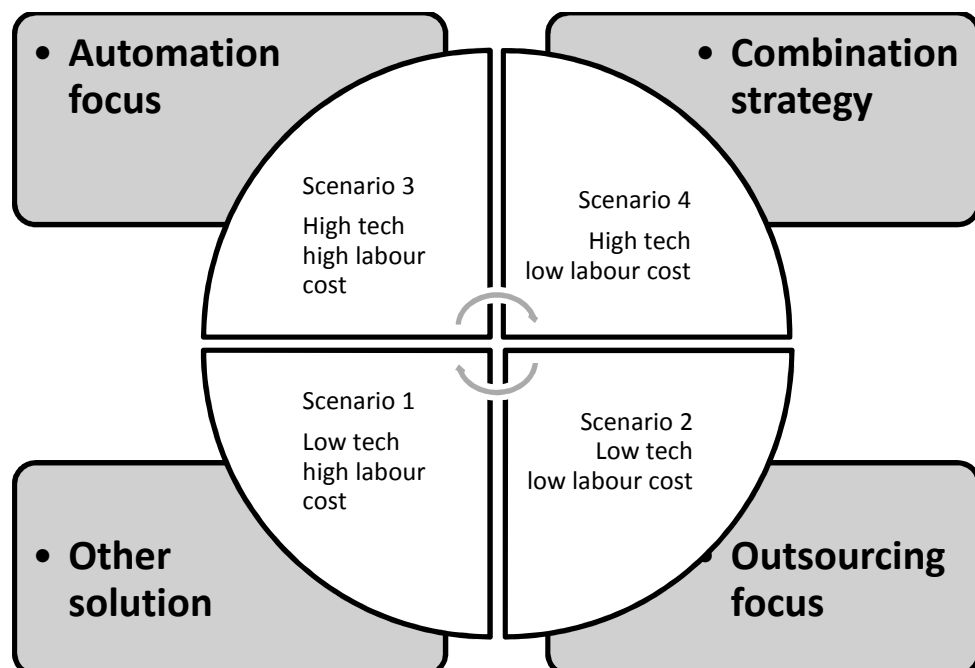


Figure 21. The strategies associated with future scenarios of garment assembly.

### *Scenario 1: Other solution*

For scenario 1, it represents both the outsourcing and automation strategies are not welcomed. There are decreasing practices of outsourcing in the industry. At the same time, the automation assembly strategy is in very low level or fails totally.

Other option has to be considered as both automation and outsourcing are not viable options. Other solutions such as foreign direct investment, vertical integration, near-shore outsourcing and quit the business etc. are examples. For instance, moving back the manufacturing process to the company while the production can be under control is a possible solution. Also, foreign direct investment, it is an option to stay the business in a foreign country while the whole assembly process is under own control. However, there are still many problems considering other solutions. As not every company has the financial ability to buy a factory, especially for the small and medium sized one, and the labour cost is still high even the company has the ownership of the factory. Thus, the decision need more consideration and planning, as it is out of the objective in this paper, the recommendation is not intensely discussed here.

### *Scenario 2: Strategies in outsourcing*

In scenario 2, outsourcing is remaining dominant. There are small adoption of automation but slightly or no influence to outsourcing activity. It can also represent zero movement of automation in the extreme case.

As automation is not favorable in this situation, outsourcing is still widely selected in the garment assembly industry, which is much the same as the current situation. The suggestions would be mainly focus on solving the challenges in outsourcing. The supplier relationship management with the portfolio approach is a viable strategy.

In addition, selective outsourcing could be determined based on the product nature in terms of fashion-consciousness. As Kumar and Arbi (2008) mentioned, outsourcing is not a viable solution for meeting short-term market demands but for large seasonal orders, outsourcing could be a big cost-saver. Hence, following this idea, for less fashion-conscious products, the basic and seasonal items, it should continue with offshore outsourcing to the low cost countries. However, for fashion items, far away offshore outsourcing is not a suitable strategy; therefore, near-shore suppliers should be considered. This is exactly the idea of double sourcing strategy.

### *Scenario 3: Strategies in Automation technology*

In scenario 3, automation becomes dominant in the future garment assembly manufacturing, while outsourcing is fading out. The industry widely adopts the automation practice and companies give up the outsourcing practice gradually. The

attention should be focus on the investment and implementation of the automation technology.

The investment of automation technologies varies among the types of production systems. Different system has its own features to suit different product types. The classification of garment product in assembly manufacturing depending on complexity includes product type i.e. T-shirt, jeans or jackets and material i.e. cotton, wool or silk, also in terms of fashion consciousness i.e. basic or fashion items, and production volume.

Depend on the technological factors in automation technologies development, the three basic types of production automation, fixed, flexible and programmable automation suitable for different product types. Basically, fixed automation is more suitable for basic non-fashion conscious items. Flexible and Programmable Automation is better for the fashion items which has higher variation. As in garment product, the basic items are usually in fixed structure with simple and less variation, it is suitable with fixed automation which has high production rates but less flexibility. For fashion item, it has rather higher design variation and relatively lower in volume, therefore, programmable automation and flexible automation which have lower production rates but higher flexibility are more suitable.

Besides, fully automation may not be the best result in the early stage of implementation; therefore, Right-Automation concern the appropriate level of automation is vital in this stage. In order to achieve the balance of automated and manual assembly operations combination, complete analyses of the manufacturing process including costs, quality, productivity and flexibility is necessary. The migration from automated production to automated integrated production strategy should be planned and carried out gradually.

#### *Scenario 4: Combination strategies*

In scenario 4, the automation and outsourcing strategies are both welcomed in the industry for garment assembly and working out together. In this situation, automation assembly is widely adopted, but outsourcing is still keeping in the same position at the same time. Two situations could be under this circumstance.

The first situation is a company can still outsource the garment assembly to a supplier, but with the supplier who has invested in automation technology. In this case, the company can still enjoy the other benefits of outsourcing and avoid the risk in automation investment. The production is out of the labour factor effect, but there are still problem in slow responsiveness and other related issues in supplier management.

Another aspect is the products are partly outsourced to supplier with manual labour factory and partly automated on its own factory. The company automates according to the product types, for example, investing automation line for fashion product, outsourcing basic and seasonal fashion items to an outsider. In this situation, Automation replaces the high labour cost in the home location, to reduce the high labour cost but enhance responsiveness for fashion items, at the same time, the company can still enjoy the low cost benefits when outsource basic item to low cost countries. This is a partial outsourcing concept combine with developing plants with automation technology. This suggestion accomplish with Bengtsson and Dabhilkar (2009) opinion, not using outsourcing as an isolated and alternative strategy, but in combination as a complement to further develop internal manufacturing capacity and capability.

### 5.3.2. Strategic postures and moves

Referring to the research question in this paper, the aim is not to find out whether outsourcing can be replaced by automation in garment assembly aspect only, but also the strategic actions for it. Therefore, a more strategic recommendation should be emphasis on the scenarios 3 and 4 where automation technology can be realized.

Based on the Courtney et al. (1997)'s uncertainties level framework, it is confusing to define whether the future of garment industry should lie on the uncertainty Level 2 or 3( Figure 22). Level 2 described alternate futures in which a few discrete outcomes is determined. Level 3 proposed a range of futures with a range of possible outcomes, but no natural scenarios.

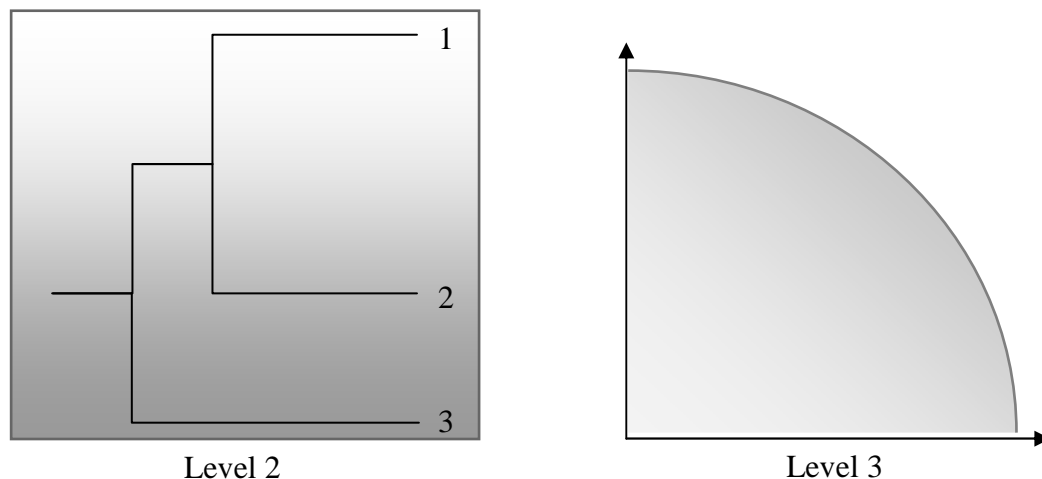


Figure 22. Level 2: Alternate futures and Level 3: A range of futures. (Courtney et al., 1997)

When considering the scenarios, automation and outsourcing seems to be discrete concepts, they set into two sides of the scenarios. Level 2 proposed discrete scenarios, a discrete scenario means they are not continuous or connected to each other. However, in

scenario 4, there are connections as they can be combined to serve the garment assembly manufacturing together. Hence, the scenarios are not fitting totally to the Level 2 uncertainty.

Level 3 proposed a range of future but no discrete scenarios. Example from Courtney et al. (1997) mentioned for the uncertainty in the field driven by technological innovation, when company deciding whether to invest in a new technology, producers can often estimate only a broad range of potential cost and performance attributes for the technology and the overall profitability of the investment depends on those attributes. This is a similar situation to the automation of garment assembly, which relies on technology innovation. The key variables functional performance and potential cost could only be estimated in a broad range, the actual outcome may lie anywhere on these range. In this point of view, the scenarios fit into Level 3 uncertainty.

The future scenarios generate few possible situations in the garment assembly manufacturing industry. The decision of managers varied from the company's strategic postures and it derived different moves. Based on the postures and moves approach from Chapter 2.2.1, the selection of managers is analyzed under these two scenarios. As the future of garment assembly manufacturing is a level 3 uncertainty which has a range of future. Accepting this to the strategic postures and moves analysis, Courtney et al. (1997) discussed the three strategic postures in level 3 uncertainty have the following moves:

1. *A shaper in level 3 tries to move the market in a general direction because they can identify only a range of possible outcomes. It's shaping posture is backed by big-bet investments in product development, infrastructure, and pilot experiments to speed customer acceptance. (Courtney et al. ,1997)*

For the companies who take the shaper postures, it should be a large company who has more financial backup and professional to plan and support this decision. They are also more technology driven then cost conscious. They will take a big bet investment in the automation technology; hence sufficient financial situation to bear higher risk in uncertain market is needed.

2. *An adapter posture at uncertainty levels 3 is often achieved primarily through investments in organizational capabilities designed to keep options open. Because they must make and implement strategy choices in real time, adapters need quick access to the best market information and the most flexible organizational structures. They don't have the deep pockets and skills necessary to set standards. (Courtney et al. ,1997)*



The company with adapter posture is usually more cost conscious medium scale company. Even they are technological driven company, but insufficient financial background restricts them to pay a big bet. Yet, they still want to be the first group ahead to achieve the new technology. Therefore a balance between positive payoff and negative outcome is needed to survive in the market.

3. *Reserving the right to play is a common posture in level 3. Making incremental investments could provide useful information, and it would put the company in a privileged position to expand the business in the future should that prove attractive. By restructuring decision from a big bet to a series of options, the company reserved the right to play in a potentially lucrative market without having to bet the farm or risk being preempted by a competitor. (Courtney et al. ,1997)*

Company which is more cost conscious than technological driven usually takes the reserve the right to play option. It is not necessary a small company, large company prefer more stable and secure move is also taking this place.

It seems that the no-regret move is not recommended, especially for technological investments which bear a huge amount of money and changes. It is a radical technology changes in form of production totally.

In addition, the strategic move stands on the concept of the first mover strategy for pioneering in technology innovation or implementation. The first mover in the market usually set the standard and captures the market share in the first place. However, the benefit as a first mover in adopting garment assembly automation is vague. As the garment assembly is the final part of the production process, it is just a need but does not add any additional value to the product's design or function. Even though, there are arguments on better quality with automation production than manual labour, it is not for surely proved. Instead, manufacturers can increase the brand image in the social responsibility aspect, by supporting on automated production and against the 'sweatshop' factory. Hence, first mover strategy could be advocate in such case.

## 6. CONCLUSIONS

### 6.1. Research summary

This study motivated by the accusation of outsourcing garment assembly to low cost countries for decline in European garment manufacturing industry and the root cause is the difficulties in automation. Nevertheless, the LEAPFROG project brings the good news upon the radical technology innovation of 3D sewing technology which has promising high possibility to realize garment assembly automation. It projects a great hope for the future garment assembly manufacturers in Europe. Moreover, as this study is motivated by the curious towards its intention of replacing outsourcing by automation for garment manufacturing, the main research question is whether outsourcing can be replaced by automation as a manufacturing strategy for garment assembly in the future.

The summary of this study is divided into two aspects. The first one is to evaluate the effectiveness of the two alternative strategies: outsourcing and automation, for assembly manufacturing. The other one is the analysis of the future of garment assembly, in accordance with the recommendation of manufacturing strategies.

In the first aspect, with the reflections from literatures, the comparison of outsourcing and automation as the alternatives strategy for manufacturing are recognized from the contradictions between the driving forces and consequences of each alternative exclusively. The contradictions reflect the effectiveness of the alternatives for manufacturing strategy selection. The comparison was explained under the manufacturing objectives cost, quality, delivery and flexibility. They are the most common criteria for judging the effectiveness of a strategic choice for manufacturing. The alternative strategies for manufacturing, outsourcing and automation, are analyzed under these four criteria in respect of garment manufacturing industry.

First, the comparison showed that both outsourcing and automation can save the labour cost, however, they bare extra cost for implementing the strategies itself. Outsourcing bares hidden cost especially under problematic contracts, automation have investment cost and extra operation cost. Hence, the comparison cannot be examined until the induced costs are fully revised. Second, the quality of the products cannot be guaranteed for both outsourcing and automation. For outsourcing, as the quality level depends on the initial selection of suppliers and their contractual enforcement. Even though machine may have higher guarantee for quality in automation, the possibility of error

from the interaction with human cannot be overlooked. Therefore, full guaranteed of good quality is not possible for both alternatives.

Third, outsourcing can have faster delivery only when using double sourcing strategy which divided the fashion and non-fashion conscious product to separate suppliers for differential responsiveness. Automation seems to be more promising with shorter production lead time, as machine are expected to be faster than human, as well the production site is able to locate close to the sales market for shorter distribution lead time. Forth, outsourcing is flexible with many options of suppliers but become inflexible once the contracts are made. With flexible and programmable automation, manufacturing flexibility could be high, however, it is limited to the functional development of the automation machinery. All the parameters of automation are not yet guaranteed until the dominant technology is tested and accepted.

In terms of cost and quality, both alternatives are not recommended as a better option of manufacturing strategy than each other. In terms of delivery and flexibility, automation seems to be a better choice. However, the later on analysis show that, fully automation may not be the best option and combination of two alternatives could be superior.

In the second aspect, the outcome includes scenario development and scenario planning. The scenario development concern the future of garment assembly manufacturing which is projected based on two uncertainties: the availability of labour and technology. The high labour cost in Europe is the driving force for outsourcing and automation, the unclearness of future labour factor form the first uncertainty. On the other hand, since the root cause of outsourcing is the unavailable of technology in automation, thus, the ambiguity of technology development form the second uncertainty. Accordingly, the four scenarios concerning are generated under the GBN matrix technique in accordance with the labour and technological uncertainties. The four scenarios illustrate the future of garment industry in respect of the combinations of different level of labour supply and technology.

The scenario planning comprised the recommendations for individual scenario which are formed with the combination of manufacturing alternatives. The four strategies: other options, outsourcing focus, automation focus and combination strategy are suggested. The scenario planning also suggested strategic moves and postures for company, in respect to the level 3 uncertainty which projected a range of future. The scale, financial status as well as attitudes of technological advancement distinguish the strategic moves of a company. For instance, the first mover strategy is more suitable for the fashion company with better financial status and higher attitude toward new technology.

The summary of this study answer the research question with the conclusion that even automation can be realized, outsourcing is still needed, in the predetermined time frame. It could be realized that one day the labour cost around the world is not cheap anymore, automation is a viable solution. But the transformation stage is long and implementation takes times. Also as other researcher mentioned, fully automation may not be the best option. The right automation for balancing the manufacturing efficiency and automation is needed. Human operator is still needed in monitoring the machinery. Furthermore, the plant performance is better when using outsourcing collaborate with internal manufacturing capacity and capability development, in line with automation in this case. Therefore, outsourcing and automation are better when they are combined and collaborate with each other as manufacturing strategy, at least in the decided period of time.

The LEAPFROG project have only point out the one way of replacing automation by offshore outsourcing, they have not drawn attention to the possibilities of combination of both. More importantly, they have not considered that the suppliers in low cost countries can implement the automation assembly as well. It is because they have only considered cost reduction is the only reason of outsourcing. In fact, core competence can be a more important driving force for outsourcing. Hence, if the European companies are not only concern on the manufacturing cost for outsourcing, they want to get rid of the manufacturing process completely, they may not replace outsourcing by automation. Indeed, they can still choose a supplier with the automation assembly capabilities for production.

## **6.2. Research limitations and future research potentials**

This study carried out with a self-enhanced attempt to analysis the manufacturing strategy for garment industry in the future. It is inspired by the research from LEAPFROG project from European Union. Even though, the analysis of this research is relying on secondary resources, there is lack of support by primary empirical data. Therefore, there are possibilities to acquire primary empirical data through industrial opinions concerning the automation technology. Research method such as focus group discussion, questionnaires and interviews on the industrial acceptance towards new technological acceptance could be carried out. Also, as the motivation of this paper arises from the European LEAPFORG project, it would be an opportunity to conduct comments from the researchers and editors from the project. The possibilities of interviews and discussions provide potential for deeper research in this aspect. Also, the recommendation can be more focus and detail, the recommendations and the strategic plan and moves regarding the scenarios are not discussed thoroughly. A more detailed investigation in the industry aspect with empirical data can be carried out.

Moreover, as the GBN matrix technique used for scenarios development has a limitation that it is not possible to fully characterize the uncertainties of the future with just two dimensions. Therefore, some other uncertainties maybe underdetermined. Other types of technique could be employed for scenarios development.

Besides, studying on the future may not be verified until the future has come, as the proposed time period in this research is more than 10 to 20 years, it is impossible to test the validity at the moment. As this research is based on a major uncertainty in the garment assembly automation technology, the future development of this innovation would change the direction of the scenario. Hence, as whenever the prominent improvement in the technology, the scenarios could be reviewed and edited to a more suitable picture. In addition to garment assembly manufacturing, the future of assembly automation in other industry could be investigated as well.

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