The Relationship between Lean Manufacturing & Customer’s Demand Uncertainty

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Customer Demand Uncertainty is a big obstacle for companies to sustain their competitiveness in the market that responding customer requirements becomes essential. Besides companies need to consider also their cost structures which should have in high consistency to survive as well. Lean and Agile terminologies have been investigated so far in cost and responsiveness to customer manner within internal system perspective i.e. product volume and variety. This thesis aims to link lean manufacturing steps with customer demand uncertainty condition following information systems, marketing issues and human factor for management level in framework that firm’s (manufacturer) current condition can be tested according to answers from questionnaires and implementation of assessment tables since it is used as guideline and provides on which level firms are in demand uncertainty, lean and agile manufacturing. This support enables to firms to create their own flexible leagile decoupling point according to their interior characteristics and capabilities in the market.
THE RELATIONSHIP BETWEEN LEAN MANUFACTURING & CUSTOMER’S DEMAND UNCERTAINTY

SUMMARY

In highly competitive environment, the companies need to try some responsibilities to continue their sustainability in the market. Satisfaction of customer requirements within agreed time, high quality and service levels are essential point to keep firms positions. On the other hand reduction of cost in the system is another perspective to survive hence those characteristics; customer responsiveness following cost reduction in the system conducts the firms to take some decisions and responsibilities in the changeable market conditions. Many literature studies have been discussed that lean terminology provides elimination of waste and cost reduction in low variety and low demand uncertainty while agile terminology is important to provide quick customer responsiveness in high variety and high demand uncertainty. Nevertheless external integration between supply chain members would be determinant since it facilitates to overcome for uncertainty.

The purpose of this thesis is to link lean manufacturing steps with customer demand uncertainty including marketing issues with integration of agile manufacturing since agile enables to gain quick responsiveness in highly demand uncertainty while lean conducts cost reduction. This aim is carried out of development of framework which depends on four categories; lean and agile concepts in manufacturers, support of information system, suppliers contracts and marketing issues. This framework helps organizations in customer demand uncertainty situation that provides to make decisions. Besides the recommended framework questionnaire and assessment tables are developed to describe company’s condition on which level it has lean, agile and demand uncertainty since it helps to follow this framework.

Leagile systems are used in manufacturer part in this framework that consisted of three parts; system, strategies and people to deal uncertainty thereby flexible decoupling point is placed accordingly. By doing so, the sections under each part can be determined according to company’s own system and characteristics with combination of supplier contracts, marketing issues and information strategies. In order to identify company’s characteristic, questionnaire and assessment tables are implemented to managers and answers clarifies the companies situation how far they are in demand uncertainty, lean and agile manufacturing where the questions can be either explicitly or implicitly related with them. Therefore results and conclusions for this report are a framework that supports to deal with uncertainty with placing leagile flexible decoupling point where the determinants are obtained from answers of questionnaires and assessment tables. These conclusions can provide to gain adaptability in highly competitive environment and possible cost reductions are acquired that can be considered in terms of efficiency and effectiveness points in the system.
THE RELATIONSHIP BETWEEN LEAN MANUFACTURING & CUSTOMER’S DEMAND UNCERTAINTY

KEY WORDS
Demand Uncertainty, Marketing, Lean Manufacturing, Agile Manufacturing, Decoupling point
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Muhammad Abid and Senol Özkan
1 INTRODUCTION

The background of customer demand uncertainty is interrelated both customer responsiveness and marketing issues that external uncertainty in supply chain becomes essential between partners. In this chapter, description of background of research area is stated that based on customer demand uncertainty in competitive environment with agile and lean manufacturing. Furthermore purpose and aims, delimits and outline of thesis are presented.

1.1 BACKGROUND

In order to satisfy customer requirements, responsiveness of the customer is crucial to sustain in competitive environment. Ability of meeting demands for customer in shorter delivery times and struggling the peaks and troughs of demand becomes critical. (Christopher, 2000) Today’s competitive environment can be stated as fulfilling the individual customer needs to obtain competitive advantage which is resulted incremental product variety. (Zäpfel, 1998) Moreover supply chain integration would be notable point in this condition since that plays critical role in customer responsiveness. Better customer satisfaction and market understanding depends on some components such as demand forecasting, inventory and responsive supply chain. (You and Grossmann, 2008)

To overcome demand uncertainty firms try to take some responsibilities that supply chain performance is unpredictable and some safety mechanisms are searched to protect against disturbances. (Geary et. al, 2002) Those activities induce increased cost due to the effects of uncertainty since lack of visibility and communication occurs between participants of supply chain. In supply chains, inventory facilitates to struggle with demand uncertainty since it improves the service and provide flexibility even though it can be costly. (You and Grossmann, 2008)

Agile manufacturing is described to overcome fluctuations of demand within product volume and variety that uses market knowledge and a virtual corporation to sustain in volatile market places. (Naylor et. al, 1999)

Lean manufacturing consisted of doing more with less (Christopher, 2000) and basically focuses on zero inventory level according to just in time approach. Lean is described as a best match in circumstance of low demand uncertainty that cost is the major order winner in competitiveness. (Waddington et al., 2001-02). In lean, the focus is on elimination of waste and achieving delivery of standards and staple products with low cost. (Stratton and Warburton, 2003) Lean operations depend on level scheduling and there is an absence of variety hence demand uncertainty is resulted in appearance of agility. (Stratton and Warburton, 2003)
Marketing strategy is important to arrange the current system characteristics that provide a clue for the firms for their manufacturing strategies. It facilitates to describe key competitors, definition of user characteristics, and assessment of buying behaviors which are associated product volume, variety, and level of innovation. (Hill, 2000)

1.2 Purpose and Aims

Customer Demand Uncertainty including lean and agile paradigms has been widely investigated so far and there are available research studies regarding this area. Basically lean and agile paradigms for decoupling points are mostly considered in product volume and variety in terms of internal uncertainty. Therefore there is a necessity of research are based on external uncertainty that leagile approach is recommended as a flexible point in this concept. This report tries to combine suppliers and manufacturers in customer demand uncertainty condition by following information systems, supplier contracts, marketing issues and human factor for management level in framework. Moreover the questionnaire is applicable that answers from managers can clarify the firm’s position for competitiveness in terms of demand uncertainty, lean and agile manufacturing since it is used as guideline.

We investigated the following two research questions:

RQ1: What factors of lean manufacturing / philosophy relates with customer’s demand uncertainty?

RQ2: How to achieve lean philosophy in customer’s demand uncertainty situations?

1.3 Delimits

This report focuses on external view that customer demand uncertainty is described as an external factor throughout supply chain rather than internal factors in production process activity. This principle is also used in lean and agile manufacturing that shop floor activities are excluded in this manner.

Lean and agile paradigms are considered in logistic process with supply chain concept that contains integration and collaboration of suppliers and manufacturers which are essential and focus on customer value.

1.4 Outline

The outline of thesis follows the steps as mentioned below in each chapter.
Chapter 2 - Research Methodology

This chapter represents the chosen research methodology including data collection, research techniques and research process.

Chapter 3 - Literature Review

Literature Review is consisted of marketing, demand uncertainty, lean and agile manufacturing including lean and agile supply chains with leagile and decoupling point in order to identify the topic since it provides good understanding to make analysis conclusions for this report.

Chapter 4 - Analysis

This chapter contains 3 sub-analysis topics by following:

- **The Factors of Lean Manufacturing Relates with Customer’s Demand Uncertainty**
  This part analyses the relationship between lean manufacturing and Customer Demand Uncertainty by connecting lean tools with external uncertainty

- **Parameters of Customer’s Demand Uncertainty**
  In this part, parameters of Customer’s Demand Uncertainty is stated that information, products and contracts/alliances are core concepts which plays important roles in customer’s demand uncertainty situations.

- **Parameters Relates Leagile Supply Chain and Customer’s Demand Uncertainty**
  Alike in previous part, related parameters regarding Leagile Supply Chain and Customer’s Demand Uncertainty are stated.

Chapter 5 - Conclusions and Discussions

In this chapter, conclusions are presented by following framework and questionnaire and future research topics are discussed.

Chapter 6 - References

List of references list are gather in this chapter
Chapter 7 – Attachments

In this chapter we enclosed questionnaire, categories of demand uncertainty, lean manufacturing and agile manufacturing. Assessment tables are also enclosed in this chapter.
2 RESEARCH METHODOLOGY

This chapter mentions about chosen research methods and techniques which are presented in report with reasons and explanations of why they are appropriate for research methodology that is supported from theory.

“Research is an organized, systematic, data-based, critical, scientific inquiry or investigation into a specific problem, undertaken with the objective of finding answers or solutions to it.” p. 4 (Sekaran, 1992) “The term ‘research’ is often defined in terms of systematic inquiry.” p. 1 (Verma and Mallick, 1998)

“Simply expressed, research involves finding out something which was previously not known, or shedding fresh light on an issue or problem” p. 1 (Verma and Mallick, 1998)

2.1 METHODOLOGY APPROACH

2.1.1 Qualitative Approach (Inductive approach for analysis)

In order to perform this research, the necessary data is gathered based on theoretical studies and literature reviews which depend on the books and articles. Fink (1998) states “A literature review is a systematic, explicit, and reproducible method for identifying, and interpreting the existing body of recorded work produced by researchers, scholars, and practitioners.” p.3 Accordingly, literature provides a way to find out where to get support for the research and describes and justifies what a researcher has done.

In this research, qualitative approach is preferred due to the generating of new hypothesis (questionnaire, assessment tables and framework) and collection of data from the theory and literature. Williamson (2002) mentions about the qualitative approaches to research are mainly linked with interpretivism and “Interpretivist approaches are associated with inductive reasoning.” p.26 Another explanation regarding inductive reasoning as induction which is “a method of creating knowledge whereby researchers /consultants/ investigators conclude general laws from individual cases, that is, construct theories using factual knowledge.”(Arbnor and Bjerke, 1997, p.92) Hence “Inductive reasoning is associated with the hypothesis generating approach to research.” (Williamson, 2002, p.27) Interpretive research is also described as flexible design that problem, data collection, analysis and development concept has been interrelated by double direction rather than downstream direction as respectively. That means research may be modified or upgraded due to the new development concepts by gaining new ideas and thoughts.

Arbnor and Bjerke, 1997 also mentions about system analysis. According to them “the creator of knowledge formulates the problem” p.301 and “Using system analysis means to reproduce the pattern and to determine the finality
relations of a real system.” p.301 In this research, demand uncertainty was described in terms of lean terminology perspective since lean cannot be effective in unpredictable demand under normal conditions. Afterwards researchers had realized that agile paradigm was a good solution to overcome uncertainty problem then leagile paradigm became clear picture either combination for lean concept in terms of elimination of waste, low cost and high efficiency or for agile concept increased customer responsiveness. Finally lean-agile-demand uncertainty concepts were combined with marketing issues and the research approach was executed in this whole. Accordingly, “system analysis concentrates on the whole”, “the parts can be explained and understood only in relation to this whole” also “reproducing the relations among the parts and between these and environment of the real system.” (Arbnor and Bjerke, 1997, p.301). Another issue is being prepared to the revising the system due to real system necessarily changes according to them.

As mentioned above, reproduced relations provide a possibility of extensive analysis since it enables to revise processing for the researchers. This reversibility implies possibility of flexible design which follows the interpretivism and qualitative approach. Nevertheless “Research design therefore tends to be non-linear and iterative” p.32 that emerges iterative process and emphasizes the interconnectedness of the stages. (Williamson, 2002)

Moreover, this research project methodology can be evaluated from the system approach which focuses on the whole perspective. According to (Arbnor and Bjerke, 1997) states a system is arranged in kind of way that the whole differs from the sum of its parts. Figure 1 implies all factors are considered in total perspective that the parts are not only enough but also their relationships become essential. Parts are explained (sometimes understood) by the characteristics of the whole. (Arbnor and Bjerke, 1997)

![Figure 2.1 The System Approach Synergy](image)

Figure 2.1 The System Approach Synergy –The Whole Differs From the Sum of Its Parts (Arbnor and Bjerke, 1997)

In the concept of research, the identified problem depends on the four different topics (individual actors) which are lean, agile, demand uncertainty and marketing issues. Those topics are harmonized and each of them is
interrelated with each other in terms of concentrating the whole rather than summing up each of them separately.

Researchers initially performed the components in order to get whole picture. During obtaining for whole standpoint, components were considered via their advantages such as agile paradigm focuses on responsiveness while lean concentrates on elimination of waste, low cost and efficiency. Then marketing and demand uncertainty were combined in this whole consequently. That implies the system components roles determine the plan since the whole was consisted of each of them and their relationships inherently.

![Diagram](image.png)

**Figure 2.2 The System Approach Synergy: Customer Demand Uncertainty in Terms of Lean Philosophy**

### 2.2 Research Techniques

Research techniques in this study depend on collection of secondary data and literature review which are basis of this thesis and qualitative approach. Secondary data collection is implemented due to the only data sources from books, articles and journals which implies literature review since there is no way to collect different type data i.e. quantitative data. Nevertheless data sources are tried to be evaluated in terms of eligibility points.
2.2.1 Collection of Secondary Data

In this study, collection of data depends on the secondary data instead of primary data due to literature reviews (books and articles) which are only data resource to carry out this research. Cryer (2006) states regarding secondary data as already collected by other researchers and likely already published.

“A type of secondary data is increasing considerably in importance with the expansion of research internationally and the trend to storing research data in internationally available databases, is that form previous researchers studies.” (Sharp et. al, 2002, p.160) Hence “If the basis on which previous studies have been conducted has been properly documented, and there has been reasonable standardization in the way data were collected, then it becomes possible for researchers to base the analysis entirely on the data from previous studies.” (Sharp et. al, 2002, p.160)

2.2.2 Literature Review

Literature search can be consisted of many resources such as books, articles and journals. In this research, many books and articles are reviewed, read and analyzed. After election of those sources; numbers of literatures are used for this research which was put on the reference list as well.

According to Fink (1998), “A literature review is always filtered through two eligibility screens.” p.52 those are practical and quality screen. Practical screen provides usability of literature in language that researcher read, in appearance that researcher respects in timely manner. (Fink, 1998) “The second screen is for quality, and it produces the best available studies in terms of their adherence to the methods that scientist and scholars rely on to gather sound evidence.”(Fink, 1998,p.52). That means quality screen is essential to meet selected standards and describes how they are scientific. In this study, language was the practical screen perspective that researchers focused on the literature which was written English. For the quality screen, there is no obvious identification regarding literatures how they have been in high quality. Besides the data gathered from literature depends on books, articles and journals which were collected mostly from library and also from internet. Any of literatures has not been tested according to quality screen.

2.3 RESEARCH PROCESS

The research was carried out from middle of March till middle of August. Before beginning of this research study, the courses were analyzed which had been taken so far in Production Development and Management program with researchers previous background in bachelor degree. After reviewing the courses, the ideas are discussed between researchers and proposal was
offered to the program coordinator. After getting confirmation regarding the research topic, related literature reviews were started to be collected either from different books and articles.

Many books and articles were handled and read regarding the research topic area afterward literatures were started to be elected in order to identify exact resources which wholly corresponded with research topic.

After collecting data from literatures, different thinking ability was gained and different ideas were created for building analysis and the aim was to propose possible solutions for the problem. Much revision was done due to reading and gaining different ideas and process was conducted iterative rather than linear since literatures had given some potential clues for analyzing then these clues started to be researched again from another literature. Afterwards possible combinations were discussed by researchers iteratively then the ideas were shared with supervisor.

By doing so, analyzing of research was implemented as equivalent as amount of knowledge from literature review due to obtained deep understanding and ability of creating ideas.

At the end of the research process, the study implemented up to now was concluded and discussed.
3 LITERATURE REVIEW

This chapter starts with marketing issues followed by explanation of uncertainty. Lean philosophy, agile philosophy are also described here in detail. At last leagile supply chain together with decoupling point is explained.

3.1 MARKETING

3.1.1 Marketing Strategy

Hill (2000) stated that marketing strategy includes the following three stages:

- In order to make ease in indentifying manageable units having similar marketing properties, market planning and control units must be established.

- Following are the steps involved in analyzing of product markets.

  - Establishing current and future volume.
  - Elaborating end-user characteristics.
  - Assessment of patterns having buying behavior.
  - Observing trends and practices in the industry.
  - Key competitor’s identification and reconsidering the business relative position.

- Target markets identification and set agreed objectives for each.

Hill (2000) further stated that “In addition, a company should agree on the level of service support necessary in each market and assess the investments and resources needed to provide these throughout the business. The outcome of this will be a declaration to the business of the product markets and segments that the strategy proposes and the identification of the range mix and volumes involved. Other issues pertinent to a business will include the degree of standardization / customization involved within each product range, the level of innovation and product development proposed, whether the business should be a leader or follower in each of its markets and the extent and timing of these strategic initiatives.” p. 34

Hill (2000) additionally introduced the concept of ‘order-winners’ and ‘order-qualifiers’. ‘Order-qualifies’ represents the criteria, which are essential to stay in the market, ‘order-winners’ are the ones that lead consumers to procure the product.
Johnson & Chvala (1996), the coauthors of the book ‘Total Quality in Marketing’ quoted Kolter’s four P’s of marketing called as marketing mix, the following Table 3.1 shows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
<th>Place</th>
<th>Promotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>List price</td>
<td>Distribution channels</td>
<td>Advertising</td>
</tr>
<tr>
<td>Features</td>
<td>Discounts</td>
<td>Coverage</td>
<td>Personal selling</td>
</tr>
<tr>
<td>Options</td>
<td>Allowances</td>
<td>Locations</td>
<td>Sales promotion</td>
</tr>
<tr>
<td>Style</td>
<td>Payment period</td>
<td>Inventory</td>
<td>Public relations</td>
</tr>
<tr>
<td>Brand name</td>
<td>Credit terms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Packaging

Source: Total Quality in Marketing Johnson & Chvala (1996) Pg. 159

Johnson & Chvala (1996) also explained about a survey conducted by Dick Berry in order to find out which marketing mix variables are considered to be most important by marketing, customer service, product managers and senior executives. Dick Berry added ‘S’ to represent customer sensitivity and convenience. In the following Table 3.2 Johnson & Chvala (1996) further added in the same book regarding the survey results done by Dick Berry, the table shows the four P’s and three new items together with a ranking of the managers surveyed.

<table>
<thead>
<tr>
<th>Marketing element</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Customer sensitivity: employee attitude, customer treatment, and response to customers</td>
<td>1</td>
</tr>
<tr>
<td>2. Product: quality, features, and reliability</td>
<td>2</td>
</tr>
<tr>
<td>3. Customer convenience: availability to the customer, customer convenience, easy to do business with</td>
<td>3</td>
</tr>
<tr>
<td>4. Service: post sale and presale service</td>
<td>4</td>
</tr>
<tr>
<td>5. Price: price charged, pricing terms, and pricing offers</td>
<td>5</td>
</tr>
<tr>
<td>6. Place: provider accessibility, provider facilities, and availability to customer</td>
<td>6</td>
</tr>
<tr>
<td>7. Promotion: advertising, publicity, selling</td>
<td>7</td>
</tr>
</tbody>
</table>

Schmitt (2003) also believes that the concepts such as marketing, customer satisfaction and customer relationship management all help executives to know their customers. Supply must be matched to demand in order to maximize customer service and hence market place competitiveness (Waddington et al., 2001). Schmitt (2003) forced to consider customer critically which provide a vision of total customer experience and focus on everything value during decision making. It helps managers to develop
products and services that constantly satisfied customers and provide profits for the organization.

3.1.2 Competing Challenges

(Simms 2001) argued that marketing success now depends on handling new urgency since the companies strive with global competition. (Simms 2001) stated following rules that are the most prominent for supply chain management:

- Capabilities are the ways to companies discover new paths of differentiation as the result of ‘commoditized’ markets.
- Mergers, acquisitions and organic growth are consolidating customer buying power.
- In extended enterprise suppliers must control the strength of their upstream and downstream partners.

3.1.3 Knowledge Based Marketing

Chaston (2004) stated that Richard Tedlow (1990), a business historian formulated some guiding principles in order to execute effective strategies for developing booming strategies for establishing successful mass market brands. According to Richard knowledge requirements comprise:

- In order to create high total profits the knowledge plays the key role to be able to use the economies of scale related with mass production.
- In order to use profits again in business, knowledge helps to analyze the situation in high levels of promotional activities as a system through which to form market demand.
- In order to develop a vertical system which typically involves integration within the organization, knowledge also plays a key role to integrate the procurement of materials, operations, and delivery of the products to the customer.

Chaston (2004) stated that in order to employ a successful mass marketing strategy the organizations require illustrate two sources of knowledge i.e. the knowledge of market conditions (for instance customer needs, behavior of competitors) and the knowledge to execute the operational processes. Chaston (2004) adhere the following figure 3.1 related with the elements of sources of knowledge to support mass marketing.
3.2 DEMAND UNCERTAINTY

3.2.1 Uncertainty

Clampitt et al. (2001) defined uncertainty by its opposite certainty which means something is fixed or settled and free of doubt. Crum and Palmaiter (2003) stated certain questions in order to identify uncertainty such as: “Is information, which enables making a precise enough decision about future demand, clearly known? Is basic information lacking, which makes it difficult to know the true demand picture with a high degree of certainty? Is information known but additional detail required for greater clarity? Are there multiple factors whose outcomes are unknown and interdependent, which create such a high degree of ambiguity that it is extremely difficult to judge what will happen in the future?” p. 135 (Crum and Palmaiter, 2003).
“Demand uncertainty is often a measure of the coefficient of variation (CV). In manufacturing planning and control (MPC), CV is the ratio of the demand standard deviation to the demand average and also the ratio of the standard deviation of the order arrival rate and the average arrival rate. The higher the CV is, the greater the degree of uncertainty.” p. 1 McWilliams and Tetteh (2009)

According to Clampitt et al. (2001) there are five general methods having the benefits and limitations that people use to evaluate their level of certainty, such as authorities, experience, gut instincts, reasoning, and testing. Following tables 3.3 and 3.4 shows the difference between certainty, uncertainty and degree of uncertainty retrieved from Clampitt et al. (2001):

<table>
<thead>
<tr>
<th>Certainty</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known</td>
<td>Unknown</td>
</tr>
<tr>
<td>Law like</td>
<td>Chaotic</td>
</tr>
<tr>
<td>Sure</td>
<td>Unsure</td>
</tr>
<tr>
<td>Clear</td>
<td>Vague</td>
</tr>
<tr>
<td>Predictable</td>
<td>Random</td>
</tr>
<tr>
<td>Absolute</td>
<td>Provisional</td>
</tr>
<tr>
<td>Simple</td>
<td>Complex</td>
</tr>
<tr>
<td>Stable</td>
<td>Turbulent</td>
</tr>
</tbody>
</table>


The aforesaid table shows that when situation is known, clear, sure etc. we have a certain conditions on the other hand in uncertain conditions we don’t have clear, absolute, predictable etc. situations.

<table>
<thead>
<tr>
<th>Certainty</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laws</td>
<td>Principles</td>
</tr>
<tr>
<td></td>
<td>Rules of Thumb</td>
</tr>
<tr>
<td></td>
<td>Hunches</td>
</tr>
<tr>
<td></td>
<td>Intuitions</td>
</tr>
<tr>
<td></td>
<td>Unknowns</td>
</tr>
</tbody>
</table>

Source: Embracing Uncertainty: The Essence of Leadership Clampitt et al. (2001) p. 41

3.2.2 Make to order

When the master production schedule determined by customer orders this phenomenon is called as make-to-order (Zäpfel, 1998). This strategy is successful only when the procurement of the raw material and production can be made within an agreed lead time with customers (Crum and Palmairter, 2003). In order to make Master production schedule in case make- to- stock organizations, demand forecast and inventory levels are essential elements to be known (Zäpfel, 1998). According to Crum and Palmairter (2003) some companies decided to use a make-to-order strategy for highly variable demand products but this strategy results customer service risk and inventory risks. Crum and Palmairter (2003) also believes that short leads times of procurement and production are helpful to move towards make-to-order firm.

3.2.3 Quick Response

Zäpfel (1998) believes that customer-order-driven production can keep away the uncertain situation of the products but on the same time that production system must have flexible capabilities to respond economically in unstable demand. He further stated that in uncertain demand situations a robust solution must be available for individual products. Efficient use of flexible production system and short lead times enables organizations to move towards quick response strategy (Fisher et al., 1994). By redesigning the organizational structure in order to support time compressed flows and business processes, management can achieve quick response behavior. Zäpfel (1998) Fisher et al. (1994) believe that unresponsive behavior of suppliers makes organizations difficult to achieve quick response or JIT strategy.

3.2.4 Managing Uncertainty

Zäpfel (1998) stated two production and logistics concepts in order to control uncertain demand i.e. forecast-driven production and reduction in production environment complexity.

Following tables 3.5 shows the methods of creating certainty retrieved from Clampitt et al. (2001):

Table 3.5 Methods of Creating Certainty

<table>
<thead>
<tr>
<th>Method</th>
<th>Benefits</th>
<th>Limitation</th>
<th>Tolerance of uncertainty</th>
<th>Effort level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gut instincts</td>
<td>Is expedient</td>
<td>Knowledge is limited</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Is low cost</td>
<td>May be difficult to verify notions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is spontaneous</td>
<td>May legitimize prejudice</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Authorities</td>
<td>Is expedient</td>
<td>Is only one viewpoint</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Encourages development of specialized expertise</td>
<td>Authority may feel compelled to “know it all”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frees us from becoming a master of all trades</td>
<td>Authority may venture beyond field of expertise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiences</td>
<td>Is expedient</td>
<td>Experiences may be limited</td>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Is universal (everyone has them)</td>
<td>Experiences may be misinterpreted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
<td>Is more analytical and thoughtful</td>
<td>Takes time and effort</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Is not based on prejudice or stereotype</td>
<td>Data may be missing or nonexistent</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methods may be flawed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing</td>
<td>Is objective</td>
<td>Takes time and effort</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Is open to scrutiny</td>
<td>Requires some level of expertise</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be verified</td>
<td>Results may be difficult to interpret</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methods may be flawed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Crum and Palmaiter (2003) stated following point in order to manage uncertainty:

1. By exploring additional and existing information about demand.
2. Different marketing and sales strategies can be used to develop scenarios in order to determine demand plan options.
3. For particular product lines, planning tactics can be developed based on demand volume versus demand variability.
4. If possible product lines can be rationalized and simplified.
5. The products with highly variable demand need more time and consideration from sales, marketing in planning demand.
6. Project-based businesses can exploit a planning methodology. The methodology includes go/no-go decisions regarding particular products either to be included.
7. Planning strategies must be developed to pool risk.
8. Transporting safety inventory, unstable customer lead time, and developing flexible production system and design capacity, such strategies must be defined for buffering against uncertainty.
9. Senior level management must take decisions in order to manage risk since cost and risk are involved in managing uncertainty.

3.3 Lean Manufacturing

Lean starts by focusing on determination two concepts that are aiming of better customer needs while providing utilization of less of current resources. Howell (1999) describes the Lean (according to the book from Womack, Jones and Roos; “The machine that changed the world” in 1991) as below:

“The term ‘Lean’ was coined by the research team working on international auto production to reflect both the waste reduction nature of the Toyota Production System and to contrast it with craft and mass forms of production” p.2.

In situation of low demand uncertainty where cost is the major order winner, the advantages of lean are better (Waddington et al., 2001). Excess inventory is rapidly reduced to the point where the remaining inventory levels act to smooth out the effect of the diverse sources of variation by introducing lean manufacturing (Stratton and Warbutton, 2003). “In lean manufacturing, the emphasis is on cost-cutting” p.88 (Gunasekaran 1999b). Gunasekran (1999b) further develop this thought in his same article that Lean implies very cost-efficient and productive.

Liker (2004) mentions about Toyota Production System (TPS) which is the basis for much of the ‘lean production’ movement that has dominated manufacturing trends. “Lean manufacturing methodologies are a series of techniques that allow product to be produced one unit at a time, at a formulated rate, while eliminating non-value-adding time, queue time or other delays” p.23 (Hobbs, 2003).
According to Liker (2004), TPS application starts within examination of manufacturing process from customer’s perspectives. The crucial question is asked: ‘What does the customer want from this process?’ This is related either internal customers in the next steps for production line or external customers on the final. Rotaru (2008) also mentions that customer defines the value. “Once value is clearly defining, then value streams can be clearly identified” p.121 (Rotaru, 2008).

Waste is a crucial issue which contains the meaning of the Lean Philosophy. Toyota way focuses on identifying and eliminating the waste in all work activities (Liker and Meier, 2005). A process is seen as a time line of activities, material and information flows that there is a depressing amount of waste usually far more waste than value-added activity (Liker and Meier, 2005).

3.3.1 Waste Issues

In lean, the focus is on eliminating waste and achieving low cost delivery of a standard and stable product (Stratton and Warbutton, 2003). Accordingly, Taylor and Brund (2001) describe the seven wastes which should be eliminated:

- “Overproduction
- Waiting
- Transport
- Inappropriate Processing
- Unnecessary Inventory
- Unnecessary motion
- Defects” p.28

Liker (2004) mentions about the overproduction as overstaffing and storage and transportation costs because excess of inventory. Overproduction also tends to lead excessive lead and storage times which should be diminished (Taylor and Brund, 2001). The causes of the overproduction are stated accordingly (Taylor and Brund, 2001):

- "Width and product changes, lack of modeling –seen as a result of not enough work undertaken at feasibility stage and the constraints around this part of the process
- Large trial tonnages, production record attempts, machine limitations, campaigns (laying down stock to run minimum batch quantities), just in case mentality and make to stock – all resulting in excess product and much of which was effected by the order fulfillment process
- Customer change of mind, order input errors resulting in incorrect information” p.272
Waste of waiting occurs due to the inefficiently used time which causes lower flow of goods. Waste of transport appears due to the long distances, creating inefficient transport or moving materials, parts, or finished goods into or out storage or between processes (Liker, 2004). Incorrect processing or waste of processing reveals big issues which results with long lead times, poor tool and inefficient product design coming with excessive motion accordingly. Waste of stock on hand or excessive (unnecessary) inventory takes an important part for the customer issues such as long-lead times, obsolescence, damaged goods, transportation and storage costs, and delay (Liker, 2004). Waste of movement or unnecessary motion is related the ergonomic issues regarding employees that they perform their work such as looking, reaching activities. Making defecting products is another waste category which consists of rework, scraps, repairing and inspection which results on increased cost, time and effort accordingly.


- “It reduces lead times and makes the enterprise more flexible and responsive.
- Elimination of wasteful activities frees up resources for deployment elsewhere in business. Lean thinking thus facilitates a growth strategy.” p.8

3.3.2 Just In Time

Liker (2004) describes that “Just In Time (JIT) is a set of principles, tools and techniques that allows a company to produce and deliver products in small quantities with short lead times, to meet specific customer needs.” p.23

Accordingly the power of JIT provides being responsive to the day-by-day shifts in customer demand.

“JIT aims for the total elimination of all waste to achieve the best possible quality, lowest possible cost and use of resources, and the shortest possible production and delivery lead times” p.34 (Lean Enterprise Institute, 2003).

Besides JIT is a concept that ideally tries to find to deliver products neither too early nor too late (just in time) and non-JIT Production often produces to stock and relies on forecast of demand (Zäpfel, 1998).

According to Zäpfel (1998), “The goal of JIT is to avoid stockpiles as much as possible, to produce the finished goods and immediately deliver the parts when they are needed.” p.701
For implementing this goal; short flow times throughout all process is essential.

### 3.3.3 Pull Systems

In contrast of push system, pull system is an important component for lean philosophy which means that things are done when they are required to be done not before (Carreira, 2004). Push system depends on the pushed product along the system that products are stored in forecasted demand which causes overproduction with high inventory level. Pull system is used to avoid overproduction (Liker, 2004).

Dettmer (2001) mentions regarding the pull system as:

“Pull is a manufacturing philosophy based on synchronizing production objectives and rates with actual customer demand, rather than on forecast and arbitrary finished inventory levels”.

Basically pull approaches can be count as a make-to-order approach rather than make-to-stock. In order to success with pull philosophy fast and smooth flow needs to be obtained.

According to Liker and Meier (2005) the terms ‘pull’ or ‘pull system’ are often used interchangeably with flow that they describes the differences between pull and push systems. There are following three elements of pull that differentiate it from push (Liker and Meier, 2005).

- **Defined.** A defined agreement with specified limits pertaining to volume of product, model mix, and the sequence of model mix between two parties (supplier and customer)
- **Dedicated.** Items that are shared between the two parties must be dedicated to them. This includes resources, locations, storage, containers, and so forth, and a common references time (takt time)
- **Controlled.** Simple control methods, which are usually apparent and physically constraining, maintain the defined agreement.” p.94

### 3.3.4 Kanban Systems

“A kanban is a signaling device that gives authorization and instructions for the production or withdrawal (conveyance) of items in a pull system” p. 37 (Lean Enterprise Institute, 2003)

Hobbs ((2003) states kanban methodology is a material presentation method by providing simplification of material handling and inventory management. Materials are replenished with kanban or signal instead of placed in kits into manufacturing based on production schedule (Hoobs, 2003).
According to (Lean Enterprise Institute, 2003), there are two kanban types which are production kanban (make kanban) and the latter use is termed withdrawal kanban (move kanban).

“Production kanban tells an upstream process the type and quantity of products to make for a downstream process. Withdrawal kanban authorize the conveyance of parts to a downstream process” p.37 (Lean Enterprise Institute, 2003).

Another expression is a withdrawal Kanban details the quantity which the following process should withdraw, while a production-ordering Kanban shows the quantity which the previous process must produce (Monden, 1998). In Figure 3.2 below, A, B and C products are produced in assembly line. For producing these products ‘a’ and ‘b’ parts necessary since they are produced by preceding machine line. The parts ‘a’ and ‘b’ are stored behind this line and the production-ordering Kanbans of the line are fastened to them (Monden, 1998). Then the person picks up as many boxes of this part as the number of withdrawal Kanbans from these boxes (Monden, 1998). Production-ordering kanbans are left in the store with implying the numbers of units are withdrawn. Then the information is sent to machining line that the parts are produced in quantities directed by the number of Kanbans (Monden, 1998).

![Figure 3.2 Production and Withdraw Kanban (Monden, 1998)](image-url)
3.3.5 Continuous Flow

Continuous Flow which is called as also one-piece flow describes products that move continuously through the processing steps with minimal waiting time in shortest distance which represents produced with highest efficiency (Liker and Meier, 2005). According to Liker (2004) one-piece flow creates the real flexibility. That means having more flexibility, ability to respond in short lead times and making what the customer really wants. “Changing over to a different product mix to accommodate changes in customer demand can be almost immediate” p.95 (Liker, 2004). Shingo (1989) states the benefits of one piece flow as reduced production cycle times within lower lot sizes and reduced work-in-process.

Dettmer (2001) mentions about the work balancing and one-piece flow as two key success factor of lean manufacturing. “The underlying assumption behind striving for a balanced workload and one-piece flow is that efficient management of all system components is required to achieve an efficient whole system” (Dettmer, 2001).

Liker (2004) states takt time as a heart of one-piece flow. Takt time implies the fastness of the designed cell when the one piece-flow is set up. Moreover when operations are balanced to takt time, the advantages of one-piece workflow emerge such as realizing speed and flexibility (Dettmer, 2001).

One piece flow also means that products are passed one piece at a time from one operation to the next within priority of FIFO (first in-first out) (Dettmer, 2001).

3.3.6 Continuous Improvement

3.3.6.1 Importance of Standardization

Standardization is an important tool in order to get success of sustainability in continuous improvement process. Goldsby and Martichenko (2005) state the essence of standardized work that depends on establishing best way to fulfill a task, sharing knowledge and developing the standard by continuously. Liker(2004) also explains (according to the book from Imai; “The Key to Japan’s Competitive Success” in 1986) that there is no possibility to improve any process until it is standardized. “One must standardize, and thus stabilize the process, before continuous improvements can be made” p.142 (Liker, 2004). There are three points for standardized work (Lean Enterprise Institute, 2003):

- “Takt time
- The precise work sequence, in which an operator performs tasks within takt time.
3.3.7 Takt Time

Hobbs (2003) states, “lean manufacturing line requires that a rate of flow through the pipeline be established. The rate at which work progresses through the factory is called a flow rate or takt.” p.23 Takt time is a notion that is used to design work with a function of measuring the pace of the customer demand (Liker and Meier, 2005). “Takt can be used to set the pace of production and alert workers whenever they are getting ahead or behind” p.94 (Liker, 2004). According to (Lean Enterprise Institute, 2003)

Takt Time = (available production time per day) / (customer demand per day)

3.3.8 Production Leveling

According to Liker (2004), Production Leveling (Heijunka) is the leveling of production including both volume and product mix. Liker and Meier (2005) also states the term “Heijunka” as a means to level, or making smooth. Hence by implementation of leveling the type enables quantity of production over a fixed period of time that provides to efficiently meet customer demands while avoiding batching and concluding minimum inventories, capital costs, manpower, and production lead time through the whole value stream. (Lean Enterprise Institute, 2003)

Zäpfel (1998) states that in order to avoid capacity losses and attain short throughput times, heijunka helps to reach that ultimate goal. Zäpfel (1998) further emphases that besides cross functional trained employees with flexible machinery and equipment, heijunka also requires personal policies that use cross training to balance employees’ workload.

Basically changeable customer demands forces firms to provide products when it is necessary with most efficiency and low costs. Unleveled schedule also affects the relationships with suppliers due to uncertainty of demand that supplier needs to keep a parts which causes bullwhip effect. Liker (2004) states four benefits of leveling schedule:

- “Flexibility to make what customer wants when they want it.
- Reduced risk of unsold goods
- Balanced use of labor and machines
- Smoothed demand on upstream processes and the plants suppliers.”

pp.118-119 This represents the reduced inventory and common benefit throughout supply chain.
3.3.9 Level of Automation

Level of Automation reveals flexibility of the processes to demand conditions in terms of product volume and mix. According to Liker (2004):

“IT is best to selectively use information technology and often better to use manual processes even when automation is available and would seem to justify its cost in reducing your headcount.” p.9

In this manner automation cannot be efficient while manual processes are not implemented properly. Harris and Harris (2008) present their idea regarding manual and automated processes accordingly:

“It is not a question of whether lean is manual or not- effective lean production systems use both manual and automated processes- the task is to determine the appropriate type of automation.” p.27

Nonetheless for the lean terminology, automation is also considerable in terms of elimination waste and enhancing flexibility with efficiency. Besides this, automation is also important to protect the operators from hazardous environment, sensitive products and process can be implemented through automation in high quality that implies reduction of defects accordingly (Morey, 2008). Basically automation enables the best adding value by executing harmony with human who provides tactile sensory capability (Morey, 2008). “The level of automation is often designed to support the worker” p.208 (Liker and Meier, 2005).

In figure 3.3, five level of automation is drawn that explains respectively from manual level until fully automation level.

![Figure 3.3 Five levels of automation (Lean Enterprise Institute, 2001)](image)

Figure 3.3 Five levels of automation (Lean Enterprise Institute, 2001)
As it is seen on the figure in first level every process is implemented manually. In second level except machine cycling, manual processes are followed. In third level machine cycling and unloading are automated. Accordingly at the 5th level the processes are fully automated. Moreover the great divide is seen on the figure between level three and four which reveals the monetary issues such as maintenance costs, engineering cost and cost of machine (Harris and Harris, 2008). By application of automation increases the cost while flexibility may decrease.

3.4 LEAN SUPPLY CHAIN

Stratton and Warbutton (2003) states that in order to reduce the need for protective inventory and capacity the lean supply chain paradigm implies the significance of reducing variation and enabling flow. The lean production is intending to re-design the supply chain in a way that a customer-order-driven production becomes economically feasible (Zäpfel, 1998). According to Zäpfel (1998) a systemic view of the entire supply chain and the ‘optimization’ of this system by continuous improvement is the core of lean concept which emphasizes human participation in terms of team working and creative partnerships.

3.4.1 Partnerships and Alliances with Supplier

Liker and Meier (2005) emphasize the importance of the Long-Term partnerships even though there is a short-term cost reduction. Basically this issue depends on many components with combination of suppliers. According to Liker and Meier (2005):

- Quality issue: “Toyota wants its suppliers to have a compatible culture of finding and eliminating problems through continuous improvement.” p.271
- Integration of product and process : “Integrating engineering between Toyota and its suppliers, and integrating the engineering of the product and process of the supplier, is a critical success factor, and it takes many years of investment to get right” p.272
- Suppliers needs to be stable and connected the factory’s stable plants in the value-stream to the customer values as a purpose of elimination of wastes.
- Long-term partnerships follow the innovation within product, process and improvements along the enterprise. That means Toyota works with suppliers to reach these purposes.
- “Toyota wants suppliers that are strong and capable of contributing to the entire enterprise.” p.272
  “Toyota realizes that overall financial health of enterprise depends on overall financial health of each part of enterprise.” p.272
According to Tommelein et al. (2008), lean thinking desires insertion of suppliers in design hence suppliers becomes a part of the project team. Srinivasan (2004) mentions that as a seventh lean supply chain principle in his book.

“Build partnerships and alliances with members of the supply chain strategically, with the goal of reducing the total cost of providing goods and services” p.71 (Srinivasan, 2004).

According to Goldsby and Martichenko (2005), supplier relationships should be based on long-term loyalty and agreement in concept of quality and cost reduction. On the other hand, “A supplier alliance is a long-term relationship between a buyer (e.g., owner) and a seller (e.g., supplier) that spans multiple projects and results in a more permanent supply chain to meet customer’s needs” pp. 6-16 (Tommelein et al., 2008). Gunasekran (1999) also states that the cost reduction is the basis of long term relationship with supplier in lean organizations.

3.4.2 Standardization

Liker and Meier (2005) state that aim of standardized work is a basis for kaizen according to Toyota. In order to have some foundation for evaluation and comparison point, work needs to be standardized (Liker and Meier, 2005). Standardization does not facilitate for only controlling production also gives new opportunities to do things which in turn leads them to develop better standards (Tommelein et al., 2008)

Tommelein et al., (2008) also states the importance of product and process standardization which reduces the workload related to submittals and confirmation. Moreover “use of multiples of the same product helps to alleviate matching problems, simplifies all handling, allows for risk pooling and promotes learning” p. 6-17 (Tommelein et al., 2008).

Vitasek et al. (2005) explains process standardization enables robust continuous flow that implies consistent movement of products or services throughout company’s system and customer. Moreover in standardized processes, companies can benefit from standardized products used in manufacture or assembly of goods accordingly. Hence sharing of subcomponents across the product lines is obtained that also resulting on reduced manufacturing cost.
3.4.3 Information Transparency

In Lean Supply Chains, effective communication with suppliers takes crucial part for customer responsiveness and reducing customer uncertainty. According to Levi, Kaminsky and Levi (2008), “one of the most frequent suggestions for decreasing or eliminating the bullwhip effect is to reduce uncertainty throughout the supply chain by centralizing demand information, that is, by providing each stage of the supply chain with complete information on actual customer demand.” p. 161

Tommelein et al. (2008) also emphasizes that “a lean practice is to make system status information available to those who need it, so that there is no need for guesswork or speculation (waste) to know actual demand or system status.” p. 6-17

Goldsby and Martichenko (2005) state the sharing data within the entire supply chain. According to them data sharing is extremely important that lean enterprise should be conducted in plan for sharing demand data with internal parties and external supply chain partners.

Srinivasan (2004) also mentions about importance of visibility which is important to communicate for supply chain members. Limited information causes lack of communication between participants in supply chain that they perform in their own-interest based on their forecast accordingly. Since by collaboration of sharing information enables simple forecast and actual demand becomes less erratic and easier to meet (Srinivasan, 2004). Less information sharing result more inventories and waste that created in the system (Goldsby and Martichenko, 2005).

3.4.3.1 Bullwhip Effect

Bullwhip effect is a phenomenon which reflects the effect on demand fluctuations. Jones et al. (2000a) states as:

“Bullwhip effect (Lee et al., 1997) due to the characteristics of increasingly magnified and hence worsening behavior observed upstream from the source of the disturbance.” p. 4062
According to Srinivasan (2004), even minor fluctuations in demand at the end-user or the retail level causes big variation in demand for upstream point in the supply chain. This is reflected as Bullwhip effect. In Figure 3.4, Levi et al. (2008) states “the wholesaler is forced to carry more safety stock than the retailer or else to maintain higher capacity than the retailer in order to meet the same service level as the retailer.” p. 154 This whip effect is mainly large for upstream process such as suppliers or sub processes, at the end of the whip. This magnifying effect creates necessity of having high levels of resources and cost in order to adapt demand fluctuations (Liker and Meier, 2005). Moreover reducing uncertainty can be managed via centralized demand information throughout the supply chain (Levi et al., 2008).

Figure 3.4 The increase in variability in the supply chain (Levi et al., 2008)

### 3.4.4 Third Party Logistics Providers

Third Party Logistics is an important application that providing firms delivering products faster, cheaper and smaller lots. “Third Party Logistic is an enterprise that provides such logistic services as warehousing, order management, distribution, and transport services to its customer, using its own assets and resources” p. 88 (Srinivasan 2004). Their function cannot be defined as transportation of goods also packing goods for easy distribution hence saving time later on is obtained for locating and retrieving goods (Tommelein et al., 2008).

Larsen et al. (2007) states three different types of third party logistics providers those are:

- "Asset-based logistics providers"
- "Network logistics providers"
- "Skill-based logistics providers” p. 272
Asset-based logistics providers act as an operator of the transportation vehicles such as trucks, airplanes, warehouses, terminals and containers that they also offer third-party logistics services additionally (Larsen et al., 2007). In network- logistics providers, they assure global transportation and communication networks to be able to deliver express shipments faster and more reliably (Larsen et al., 2007). These providers also work in time sensitive markets such as electronics, fashion goods and JIT deliveries. Information services contain proof of delivery and track and trace options between sender and receiver (Larsen et al., 2007). In skill-based logistics providers, physically logistics assets are not seen but only consultancy, financial services, information technology and management skills to customer are given (Larsen et al., 2007).

3.4.5 Product Characteristics

Lean philosophy basically depends on the elimination of wastes and efficiency within purpose of minimum cost. According to (Huang et al., 2002) organizations can pursue lean production terminology in terms of reduced lead time, efficiency, flexibility, cost cutting and level scheduling on supply chain. A staple product within long-life cycle is seen in this concept (Huang et al., 2002). Christopher (2000) also mentions that lean works best in high volume, low variety and predictable environments. According to Jones et al. (2000a), “Commodities that are basic products, such as tinned soups, have relatively long life cycles and low demand uncertainty due to the fact that they tend to be well-established products with a known consumption pattern. The driving force for product supply chain is therefore cost reduction.” p. 4063 The commodities are suitable with lean environment that demand is predictable thereby level scheduling can be enabled for a lean supply chain (Suzaki, 1987).

“Being a low-cost item, globally manufactured, with highly predictable patterns, profitability, can be achieved only by minimizing cost and employing a level schedule over the entire supply chain; thus, justifying the use of an LSC” p. 194 (Huang et al., 2002).
3.4.6 Supply Contracts

- **Buy Back Contracts**: According to Levi et al. (2008), the contract depends on unsold goods that the seller buys them from buyer in some agreed price higher than salvage value. This gives incentive to buyers to order more units however there is increased risk for supplier (Levi et al., 2008). In buy-back contract, selling price is specified and unsold goods back price is predetermined by supplier. Hence buy-back contracts set up dependability for unsold inventory (Sethi et al., 2005). Moreover Levi at al., (2005) states that “Buy back contracts provide such a mechanism for the supplier to share the risk with the retailer.” p. 171

- **Revenue-Sharing Contracts**: This issue occurs due to the buyer intends to have more orders in lower wholesale price and if there is no possibility to sell more units, the seller profit is diminished (Levi et al., 2008). “In a revenue sharing contract, the retailer and the supplier agree on the wholesale price, typically discounted wholesale price, and in return the supplier receives a given fraction of the revenue from each unit sold by the retailer” p. 172 (Levi at al., 2005). Thus this is resulted by incentive to reduce the wholesale price and following of increasing the amount order by the retailer.

- **Quantity-Flexibility Contracts**: In this contract; the seller provides full refund for unsold items in limited quantity that is differentiated from buy-back contracts. In buy back-contracts partial refund for all returned items is essential (Levi et al., 2008). “The amount that can be purchased on contract is bounded by a given flexibility limit” p. 13 (Sethi et al., 2005)

- **Sales Rebate Contracts**: “This provides incentive to the retailer to increase sales by means of rebate paid by the supplier for any item sold above a certain quantity” p. 128 (Levi et al., 2008).

- **Pay-Back Contracts**: “This contract depends on the situation when buyer agrees to pay some agreed upon price for any unit produced by the manufacturer but not purchased by the distributor” p. 132 (Levi et al., 2008). Since the risk increases both for manufacturer and distributor also capacity utilization increases accordingly. “The contract is designed such that the increase in production quantities more than compensates the distributor for the increase in risk” p. 132 (Levi et al., 2008).
Cost-Sharing Contracts: This contract occurs when manufacturer and distributor shares the production cost. In this contract, distributor’s benefit is the discount on the wholesale price accordingly when manufacturer decreases their cost (Levi et al., 2008).

3.5 **AGILE MANUFACTURING**

3.5.1 **Definition**

Prince and Kay (2003) quoted Baker (1996) and Hillman-Willis (1998) in order to define agile manufacturing as the capability of the organization to manufacture customized products with lesser lead time and with economies of scale. According to Christopher (2000) agility is ability in a business by which structure of an organization, logistics process and mindsets strengthen. Gunasekran (1999 a; 1999 b) defined agile manufacturing as “the capability of surviving and prospering in the competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services.” p. 1 p. 87 Christopher (2000) defined agility as the capability to react quickly in demand flexibility both in volume and variety.

3.5.2 **Explanation**

Yusuf et al. (1999) stated the key concepts of agile manufacturing such as: core competence management, virtual enterprise, capability of reconfiguration and knowledge driven enterprise. The following figure 3.5 is retrieved from Yusuf et al. (1999) article.

![Figure 3.5 The core concepts of agility (Y.Y. Yusuf, M. Sarhadi, A. Gunasekaran, 1999)](image-url)
Prince and Kay (2003) quoted Goldman et al. (1995) in order to define agility; they considered agility as a competitive strategy having following four principles in order to:

- Enhance customers,
- Improve competitiveness by improving cooperation,
- Organizing structure for change management and uncertainty,
- Understanding the advantage of people.

Prince and Kay (2003) considered waste remove as a short term strategy in order to improve competitiveness and he believed that agility helps organization in making quick response strategies in unpredictable situations which ultimately becomes cost effective. Waddington et al., (2001) also believed that in demand uncertainty situations agility is the right strategy. Gunasekran (1999a) highlighted advantages of implemented agile manufacturing such as:

- Lower manufacturing costs,
- Increase in market share,
- Customer satisfaction,
- Assist quick development of new products,
- Removal of non-value actions and
- Competitiveness in manufacturing.

Gunasekran (1999a) stated the critical concepts of agile manufacturing such as best utilization of methods and tools regarding production and management behaviors in order to become leader in competitive environment. Gunasekran (1999b) considered agile manufacturing as new way of developing business, but not as small degree of continuous improvement. Gunasekran (1999b) stated that agile manufacturing contains the following: “Rapid product realization, highly flexible manufacturing and distributed enterprise integration.” p. 88 Agile manufacturing merges the forces of stack holders in a virtual organization in order to meet market needs. Gunasekran (1999b) stated the following features must be considered for production planning and control in agile manufacturing:

“(i) Modeling of evolutionary and concurrent product development and production under a continuous customer’s influence
(ii) Real-time monitoring and control of the production progress in a virtual company
(iii) A flexible or dynamic company control structure to cope with uncertainties in the market
(iv) Adaptive production scheduling structure and algorithms to cope with uncertainties of production states in virtual company

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43
(v) Modeling of production states and control system in a virtual company and
(vi) The reference architecture for a virtual company.” p. 95

The following figure is retrieved from Gunasekran’s (1999b) article. The figure 3.6 explains agile manufacturing system which is integrated with strategies, systems, technologies and people. This can be done by rapid partnership, virtual enterprise, re-configurability and mass customization.

Figure 3.6 Development of an agile manufacturing system (A. Gunasekaran, 1999b)

3.6 **AGILE SUPPLY CHAIN**

Christopher (2000) believed that many companies that have implemented lean approach also somehow agile in their supply chain. Kruse (2002) defined agility as “it represents the vision of a value delivery system which puts the customer at the centre of all activities relating to the delivery of products and services and which entails the formation and management of fluid networks of suppliers who combine, often only on a project-to-project basis, to meet a customer’s need.” p. 19 The following figure 3.7 is retrieved from Christopher’s (2000) article. The figure explains that the agile supply chain is integrated with marketing, networking, virtual and processes.
The relationship between lean manufacturing & customer’s demand uncertainty

Figure 3.7 The agile supply chain (Martin Christopher 2000)

The following figure 3.8 is retrieved from Waddington et al., (2001) article. The figure explains that when the demand uncertainty is high agile approach is appropriate. On the other hand when demand uncertainty is low, lean approach is appropriate i.e., lean is ineffective in such situations where demand uncertainty is high.

Figure 3.8 Matching supply chain strategy to a product’s demand characteristics (Tim Waddington, Paul Childerhouse and Denis Towill, 2001/2002)

The following table 3.6 is retrieved from Waddington et al., (2001) article. The table explains appraisal of products demand uncertainty, having following four different variables:

First variable: Schedule instability, which is directly proportional to demand uncertainty.

Second variable: Variety, which increase the requirement for mix flexibility and its helps in reduction of demand certainty of specific variant.
Third variable: Responsiveness is the ability to meet customer requirements. Reduction is delivery lead times sometimes cause to increase demand uncertainty.

Fourth variable: Duration of product life cycle, shorter the product life cycle having more demand uncertainty in contrast with longer product life cycle which are more predictable.

Table 3.6

<table>
<thead>
<tr>
<th>Self Benchmarking Questions</th>
<th>Units</th>
<th>Demand Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>How unstable are the customer schedules?</td>
<td>1-Month forecast average % error</td>
<td>1 Low</td>
</tr>
<tr>
<td>How many variants do your customers require?</td>
<td>Number of variants</td>
<td>0-10</td>
</tr>
<tr>
<td>What is the customer delivery lead time?</td>
<td>Time</td>
<td>&gt;1 month</td>
</tr>
<tr>
<td>How long is the duration of the product's life-cycle?</td>
<td>Years</td>
<td>&gt;5</td>
</tr>
</tbody>
</table>

Source: Engineer your supply chain to cope with demand uncertainties (Tim Waddington, MIOM, Forward Vision and Paul Childerhouse and Denis Towill, LSDG University of Cardiff) Control December 2001 / January 2002 p. 14

The following figure 3.9 is retrieved from Waddington et al., (2001) article. The figure explains the matrix to match strategy and demand uncertainty. Since cost is the primary driver in case of lean therefore it is best suitable in low demand uncertainty situations and lean is ineffective in high demand uncertainty. On the other hand when demand uncertainty is high and service level is primary driver then agile approach is best suited in that particular situation.
The relationship between Lean Manufacturing & Customer’s Demand Uncertainty

Figure 3.9 Matrix to match strategy and demand uncertainty (Tim Waddington, Paul Childerhouse and Denis Towill, 2001/2002)

The following figure 3.10 is retrieved from Stratton and Warbutton (2003) article. The figure explains the particular type of products which are associated with two different supply chains. Responsive supply chain which is associated with innovative products deals with agile supply chain where as efficient supply chain which is associated with functional products deals with lean supply chain.

Figure 3.10 Matching supply chains with products (R. Stratton, R.D.H. Warburton 2003)

Simms (2001) considered agility as the key to survival in volatile market and he made a difference between traditional approach and agile approach supply chain, as shown in following table 3.7:
Table 3.7: Agile supply chain management versus traditional approach

<table>
<thead>
<tr>
<th>Traditional approach</th>
<th>Agile approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock is held at multiple echelons, often based on organizational and legal ownership considerations.</td>
<td>Stock is held at the fewest echelons, if at all, with finished goods sometimes being delivered direct from factory to customer.</td>
</tr>
<tr>
<td>Replenishment is driven sequentially by transfers from one stocking echelons to another.</td>
<td>Replenishment of all echelons is driven from actual sales / usage data collected at the customer interface.</td>
</tr>
<tr>
<td>Production is planned by discrete organizational units with batch feeds between discrete systems.</td>
<td>Production is planned across functional boundaries from vendor to customer, through highly integrated systems, with minimum lead times.</td>
</tr>
<tr>
<td>Majority of stock is fully finished goods, dispersed geographically, waiting to be sold.</td>
<td>Majority of stock is held as 'work in progress' awaiting build / configuration instructions.</td>
</tr>
</tbody>
</table>

Source: Creating a company for customers: how to build and lead a market-driven organization / Malcolm McDonald ... [et al., edited by Jane Simms 2001

3.7 LEAGILE

3.7.1 Definition

When decoupling point is used strategically in a supply chain between agility and leanness, this phenomenon is known as legality (Towill 2000). The ability to change rapidly is also refers as agility (Simms 2001). Towill et al. (2000) also mentioned the same concept that legaility is the combination of lean and agile approaches by strategically locating the decoupling point.

3.7.2 Conditions for Applicability

When demand is volatile this situation is associated with agile manufacturing, whereas when demand is stable this situation is associated with lean manufacturing and decoupling point is key enabler between these two approaches. It is called as leagile paradigm. According to Christopher (2000) lean approach is appropriate where demand is predictable, high product volume and low variety. Following figure 3.11 is retrieved from Christopher’s (2000) article showing the three critical dimensions of variety, variability and volume in legailile context.
According to Naylor et al. (1999) agile approach is appropriate when demand is variable and lean approach is appropriate for a level schedule. Market knowledge and positioning of the decoupling point are key enablers in which total supply chain strategy depends in legality context. The positioning of the decoupling point relates the agile and lean approaches. Towill et al. (2000) stated that for both approaches i.e. agile and lean total lead time should be minimize and product quality should be high. In long lead time there is risk to loss marketplace demand so response must be quick in volatile situations.

3.7.3 Explanation

According to Kruse (2002) lean focus on eliminating waste and efficiency driven where as Agility refers to customer driven and its drivers are speed and flexibility. Simms (2001) also believe that lean focus on eliminating waste whereas agility means flexibility in structure of the organization which is directly linked to the marketplace and with a network of supply chain partners.

Since agility is knowledge based strategy to facilitate business to progress rapidly in the new economy therefore this strategy makes stronger the link between the internal and the external business environment (Paizao et al., 2003). Simms (2001) highlighted the difference between supply chain and demand chain in order to define agility. He believed that supply chain must efficiently happen to be a demand chain, which means that all the variables such as movement, handling or production must preferably be in response to an acknowledged customer requirement. By making the difference he stated that the focal point of supply chain is to make sure the material flow form source to consumer as efficient as possible, where as effectiveness is focal
point of demand chain as it is market driven which means that demand chain responds more quickly.

Agility makes use of profitable situations in a fluctuating market by using market knowledge and a virtual corporation (Naylor et al., 1999; Towill et al., 2000). Leanness makes sure a level schedule and elimination of all waste by developing a value stream (Naylor et al., 1999) (Towill et al., 2000). Paizao et al. (2003) stated some advantages of lean production for instance reduction in prices, increase in market share, reduction in time to introduce new services, reduction in customer lead times, increase in productivity, profits and service variety. According to Simms (2001) many companies which already have implemented lean manufacturing are also agile in their supply chain. Since the shorter lead time is the key enable to reduce uncertainty and make improvement in demand plan accuracy. In order to reduce production lead times and procurement companies have adopted lean approach. (Crum and Palmaiter 2003)

### 3.7.4 Leagile and Decoupling Point

Following figure 3.12 is retrieved from Towill et al. (2000) article mentioning the difference among lean, agile and leagile supply chains. The figure explains the position of decoupling point in leagile supply chain which is in between lean and agile.

![Figure 3.12 Lean, agile and leagile supply](image)

Figure 3.12 Lean, agile and leagile supply (Rachel Mason Jones, Ben Naylor, Denis R. Towill, 2000a)

### 3.7.5 Leagile Supply Chains

Following figure 3.13 is retrieved from Towill et al. (2000) article mentioning market winners and qualifiers for agile and lean supply chains. The figure explains that in lean supply chain cost is the only market winner and quality,
lean time, service level are market qualifiers. On the other hand in agile supply chain service level is the only market winner and quality, cost, lead time is market qualifiers.

Figure 3.13 Market winners and market qualifiers for agile versus lean supply (Rachel Mason Jones, Ben Naylor, Denis R. Towill, 2000a)

Following table 3.8 retrieved from Naylor et al. (1999) article regarding different characteristics of leanness and agility after conducting industrial case studies.

Table 3.8

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Lean</th>
<th>Agile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of market knowledge</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Virtual corporation/Value stream</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Integrated supply chain</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Lead time compression</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Eliminate muda</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Rapid reconfiguration</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Robustness</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Smooth demand/Level scheduling</td>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
</tr>
</tbody>
</table>

Note: 🌟🌟🌟 = essential, 🌟🌟 = desirable, 🌟 = arbitrary.


Naylor et al. (1999) further broken down the aforesaid table into the characteristics that are of the same, similar and different importance. Characteristics of equal importance: Use of market knowledge, integrated

Following table 3.9 retrieved from Naylor et al. (1999) article regarding different metrics for leanness and agility. The table explains that the best situation would be a supply chain that could use both of these approaches.

Table 3.9

<table>
<thead>
<tr>
<th>Metric</th>
<th>Agile</th>
<th>Lean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead time</td>
<td>☀️☀️️</td>
<td>☀️</td>
</tr>
<tr>
<td>Service</td>
<td>☀️☀️️</td>
<td>☀️</td>
</tr>
<tr>
<td>Costs</td>
<td>☀️️</td>
<td>☀️️</td>
</tr>
<tr>
<td>Quality</td>
<td>☀️️️</td>
<td>☀️️️</td>
</tr>
</tbody>
</table>

Note: ☀️☀️️ = key metric. ☀️️ = secondary metric. ☀️ = arbitrary metric.

Following figure 3.14 retrieved from Naylor et al. (1999) article regarding applications of leanness and agility. The figure illustrate that in low demand for both variability in production and variety in products relates with leanness where as these two parameters are high for agility.

Figure 3.14 Applications of leanness and agility (J. Ben Naylor, Mohamed M Naim, Danny Berry, 1999)
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Following table 3.10 is retrieved from Towill et al. (2000) article stating the comparison between lean and agile supply chain. The table explains the attributes for lean and agile supply chains. There are many attributes which makes difference between lean and agile supply chains. These attributes covers products types / variety, markets to sale, information flow, forecasting etc. for instance, as seen in table below agile supply chain has ‘availability’ as customer drivers and volatile demand.

Table 3.10

<table>
<thead>
<tr>
<th>Distinguishing attributes</th>
<th>Lean supply</th>
<th>Agile supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical products</td>
<td>Commodities</td>
<td>Fashion goods</td>
</tr>
<tr>
<td>Marketplace demand</td>
<td>Predictable</td>
<td>Volatile</td>
</tr>
<tr>
<td>Product variety</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Product life cycle</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Customer drivers</td>
<td>Cost</td>
<td>Availability</td>
</tr>
<tr>
<td>Profit margin</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Dominant costs</td>
<td>Physical costs</td>
<td>Marketability costs</td>
</tr>
<tr>
<td>Stockout penalties</td>
<td>Long term contractual</td>
<td>Immediate and volatile</td>
</tr>
<tr>
<td>Purchasing policy</td>
<td>Buy goods</td>
<td>Assign capacity</td>
</tr>
<tr>
<td>Information enrichment</td>
<td>Highly desirable</td>
<td>Obligatory</td>
</tr>
<tr>
<td>Forecasting mechanism</td>
<td>Algorithmic</td>
<td>Consultative</td>
</tr>
</tbody>
</table>

Source: Engineering the leagile supply chain (Rachel Mason Jones, Ben Naylor, Denis R. Towill) International Journal of Agile Management Systems 2/1 2000b 54-61 p. 56

Following figure 3.15 retrieved from Towill et al. (2000) article stating the practical ways to achieve time compression in lean/agile supply. This figure explains the dominant and supportive applications in lean and agile supply chain. Lean is dominant in industrial and operations engineering improvements whereas agile is dominant in information and production engineering improvements. The first column shows total cycle time compression (TCT) strategies regarding improvements in different areas such as: Industrial, operations, IT and production engineering. The second column shows some techniques related with each TCT strategy, which includes reduction in setup time, design of the products, JIT, Kanban, EDI, integration of processes etc. The third column shows some examples related with each TCT strategy, which includes SMED, DFM, and reduction in forecasting errors in order to improve service level, combination of the processes etc.
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Practical ways to achieve time compression in lean/agile supply

Figure 3.15 Practical ways to achieve time compression in lean / agile supply
(Rachel Mason Jones, Ben Naylor, Denis R. Towill, 2000b)

Following figure 3.16 retrieved from Towill et al. (2000) article stating the manufacturing philosophy during the various stages of an electronic products supply chain BPR programme. This figure is the result of the case study done by Berry in 1994. The figure explains the phases of Business process reengineering and manufacturing philosophy. Lean philosophy is related with continuous flow manufacturing, global material planning system and vendor based integration into global material planning system. Agile philosophy is related with integration of sales and research and strategic use of the decoupling point.
Towill et al. (2000) stated a major difference between lean and agile approaches. He stated that “as a rule of thumb lean process tend to base the maximum capacity level on approximately 1.2 times the average demand. In contrast, an agile process may well be expected to cope with volatile demand swings between 20 percent and 100 percent of capacity. Therefore to ensure agility a process may well have been designed so that the maximum capacity level is as high as twice its average demand.” p. 59 Prince and Kay (2003) quoted Katayama and Bennett (1999) that lean and agile approaches must be considered as mutually supportive but not as competitive. Towill et al. (2000) believed that it is difficult to adopt agility in supply chain without having lean production improvements.

Following table 3.11 retrieved from Agarwal et al. (2006) article provide a comparison among lean, agile and leagile supply chains. This figure explains many different attributes of these supply chains. In addition to table 9, following table 10 provides other attributes such as lead time compression, eliminate muda, rapid reconfiguration, robustness, quality, cost, lead time and service level.
Table 3.11

<table>
<thead>
<tr>
<th>Distinguishing attributes</th>
<th>Lean supply chain</th>
<th>Agile supply chain</th>
<th>Leagile supply chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market demand</td>
<td>Predictable</td>
<td>Volatile</td>
<td>Volatile and unpredictable</td>
</tr>
<tr>
<td>Product variety</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Product life cycle</td>
<td>Long</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Customer drivers</td>
<td>Cost</td>
<td>Lead-time and availability</td>
<td>Service level</td>
</tr>
<tr>
<td>Profit margin</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Dominant costs</td>
<td>Physical costs</td>
<td>Marketability costs</td>
<td>Both</td>
</tr>
<tr>
<td>Stock out penalties</td>
<td>Long term contractual</td>
<td>Immediate and volatile</td>
<td>No place for stock out</td>
</tr>
<tr>
<td>Purchasing policy</td>
<td>Buy goods</td>
<td>Assign capacity</td>
<td>Vendor managed inventory</td>
</tr>
<tr>
<td>Information enrichment</td>
<td>Highly desirable</td>
<td>Obligatory</td>
<td>Essential</td>
</tr>
<tr>
<td>Forecast mechanism</td>
<td>Algorithmic</td>
<td>Consultative</td>
<td>Both/either</td>
</tr>
<tr>
<td>Typical products</td>
<td>Commodities</td>
<td>Fashion goods</td>
<td>Product as per customer demand</td>
</tr>
<tr>
<td>Lead time compression</td>
<td>Essential</td>
<td>Essential</td>
<td>Desirable</td>
</tr>
<tr>
<td>Eliminate muda</td>
<td>Essential</td>
<td>Desirable</td>
<td>Arbitrary</td>
</tr>
<tr>
<td>Rapid reconfiguration</td>
<td>Desirable</td>
<td>Essential</td>
<td>Essential</td>
</tr>
<tr>
<td>Robustness</td>
<td>Arbitrary</td>
<td>Essential</td>
<td>Essential</td>
</tr>
<tr>
<td>Quality</td>
<td>Market qualifier</td>
<td>Market qualifier</td>
<td>Market qualifier</td>
</tr>
<tr>
<td>Lead-time</td>
<td>Market qualifier</td>
<td>Market qualifier</td>
<td>Market qualifier</td>
</tr>
<tr>
<td>Service level</td>
<td>Market qualifier</td>
<td>Market winner</td>
<td>Market winner</td>
</tr>
</tbody>
</table>


3.8 **Decoupling Point**

Towill et al. (1999) defined the decoupling point as the position where ‘push’ flow changes to ‘pull’ flow.

Christopher (2000) defined decoupling point as the point where real demand enters upstream in a supply chain. Christopher (2000) considers it as a challenge to supply chain that to develop lean approach up to the decoupling point but further than agile approach. The point at which buffer stock is held between uncertain customer orders and smooth production output (Naylor et al., 1999).

According to Towill et al. (1999) material pipeline and the information pipeline are two flows called as distinct and basic in all supply chains. According to (Christopher 2000) there are two kinds of decoupling points called as ‘material’ and ‘information’ decoupling point. Material decoupling point lies near to final market and as far downstream. Information decoupling point lies as far as possible upstream in the supply chain. Towill et al. (1999) also argued the same that information decoupling point should be moved as far upstream as possible, it would help within the supply chain to maximize the strategic potential of the data.
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Following figure 3.17 shows the representation of the material decoupling point:

![Diagram of Material Decoupling Point](image)

**Figure 3.17 Material decoupling point (Rachel Mason-Jones and Denis R. Towill, 1999)**

Naylor et al. (1999) stated that decoupling point makes division within the organization towards customer orders from the area of the organization which is rely on planning. Longest lead time and high product variability are two factors in which the positioning of the decoupling point depends (Naylor et al., 1999). Following figure 3.18 shows the supply chain strategies retrieved from Naylor et al. (1999) article.

![Diagram of Supply Chain Strategies](image)

**Figure 3.18 Supply chain strategies (J. Ben Naylor, Mohamed M Naim, Danny Berry, 1999)**
3.8.1 Buy-to-order

If the products are exclusive, raw material also different and the products demand is inconsistent then the buy-to-order supply chain strategy is appropriate (Naylor et al., 1999).

3.8.2 Make-to-Order

In make-to-order strategy the products made from same raw material and this strategy deals with diverse locations, volumes and products mixes. Make-to-order copes with the products having variable demand and high level of customization (Naylor et al., 1999).

3.8.3 Assemble-to-Order

When decoupling point moves between manufacturers and assemblers, the supply chain strategy called as Assemble-to-Order. This supply chain strategy react to diverse customized or standard products ranges. Substantial amount of lead time is reduced and confined against the risk of obsolescence.

3.8.4 Make-to-Stock / Ship-to-Stock

These supply chain strategies deals with standard product ranges but Make-to-stock cope with in different locations whereas Ship-to-Stock strategy cope with in fixed locations. Expertise in forecasting is necessary for both strategies in order to minimize the risk of stock-outs and overstocks.

Since demand is even and products are standard at upstream level of supply chain so lean approach can be applicable. Whereas when demand is variable and products variety is more than agile approach is applicable (Naylor et al., 1999). Prince and Kay (2003) believed that lean concept should be implemented at upstream of the decoupling point whereas agile concept should be done at downstream level. Both concepts go together in order to improve performance and profitability of the organization at the operational level.

Postponement is the term which is related with positioning of the decoupling point increases the efficiency and effectiveness of the supply chain. Risk of stock-outs and excess stocks are reduced with postponing product differentiation (Towill 2000). Postponement strategies also related with effective buffer stock and are typically experienced with short life cycle products by manufacturers of wide range of products (Prince and Kay 2003). By implemented decoupling point divergence in the way of leanness and agility takes place (Towill 2000).
4 Analysis

We divide our analysis in three different parts. First, part explains the factors of lean manufacturing in customer’s demand uncertainty situations which gives the answer to first research question. Second part of analysis covers the parameters of customer’s demand uncertainty and finally we analyze the parameter which covers agile supply chain approach with customer’s demand uncertainty.

4.1 The Factors of Lean Manufacturing Relates with Demand Uncertainty

Figure 4.1 The factors of lean manufacturing relates with Customer’s demand uncertainty

4.1.1 Just In Time

In order to satisfy the customer requirements, work processes should be conducted by systematically without unnecessary or non-added value activities for whole system. Basically when the non-value adding activities are eliminated, clear picture is emerged internally for producers. Customer uncertainty appears due to the unclear or unexpected situations in absence of internal or external system factors consistency. Another expression can be stated that uncertainty occurs when external and internal factors do not meet totally for whole system. In this matter, the crucial thing is only replenishing what the customer needs and when the customer needs it. (Goldsby and Martichenko, 2005) “‘Customer” can be internal which means a work cell on the shop floor or a distribution center within the company’s logistic networks or an external customer.” (Goldsby and Martichenko, 2005, p.227)

Demand Uncertainty occurs due to the unknown demand variation or fluctuation that the firms tend to produce depending on the forecast. In this manner, make-to-stock can be appropriate since stock is held in order to
response to the customer requirements however there is also risk regarding the obsolescence issue if the products are not sold accordingly. Nevertheless, delivery is an important point which effects demand uncertainty that delivery speed, accuracy and reliability meet with customer satisfaction. Just-in-Time (JIT) is a concept which ideally seeks to deliver product neither too early nor too late. (Zäpfel, 1998, p.700) Even though product life cycle and differentiated product embraces the demand uncertainty, just-in time approach is appropriate as a target of delivery on time. It is perceptible that difficulty occurs and JIT cannot be successive 100% efficiency. According to (Naylor et. al, 1999) “In pure lean supply chain there would be no slack and zero inventory. It would be very impressive if zero inventory throughout a total supply chain was achieved.” (Naylor et. al, 1999, p.110-111)

The idea is emerged that firms can strive to be in Just-in-time approach that provide to stay in leaner concluding more efficiency and reduced cost going by iteratively. Each iteration converts the firms to stay in more Just-in-time approach and makes them more responsive to the market demand also provides gaining more effective delivery for speed, accuracy and reliability perspective by conclusion of more competitiveness in the market.

4.1.2 Elimination of Waste

Elimination of waste is the aim of lean that achievement point is the cost reduction which takes an important part for company competitiveness and sustainability in the market. Besides the integrated supply chain also can be accomplished accordingly. Naylor et. al (1999) states that “The elimination of all non-value adding processes will inevitably reduce the cost of product.” p.111 Basically there are two concepts that are more considerable regarding demand uncertainty rather than others, through 7 waste issues which are inventory and overproduction in the system.

Inventory can be necessary in some situations when product variety is high and cycle life is short. In lean, adoption of stable demand is essential. Commodities are basic products such as tinned soups, have relatively long life cycles and have low demand uncertainty and driving force for basic product supply chain is therefore cost reduction. (Jones et. al, 2000a) Hence in lean “the focus is on elimination of waste and achieving low cost delivery of standard and stable product.” (Stratton and Warbutton et.al, 2003, p.184)

In the uncertain demand situation while the products have a short life cycle and diversity, make to stock application can raise some unwanted conclusions or problems such as obsolescence. This lead to firms to have extra cost that is called obsolescence cost. “Obsolescence costs, which derives from the risk that an item will lose some of its value because of changes in the market.” (Levi et. al, 2008, p.32)
THE RELATIONSHIP BETWEEN LEAN MANUFACTURING & CUSTOMER’S DEMAND UNCERTAINTY

However Naylor et.al (1999) mentions that “A more realistic view would be to aim at a minimum reasonable inventory (MRI) where any further attempts to decrease stocks would not be worthwhile.” p.111

Information enrichment is also another point that has an effect of reducing stock levels in the system. In effective supply chain each member has a clear sight of for perceptible demand due to the information sharing. Jones et. al (2000b) states that in a traditional supply chain the retailer is the player who has a direct sight of the consumer demand which is resulted that market information is distorted initially by the retailer. This leads to firms to keep more stock levels due to uncertain demand. Moreover bull-whip effect is emerged accordingly.

Nevertheless overproduction also has a similar concept like stock on hand that is strongly related with uncertainty. According to Taylor and Brund (2001); “Senior management considered that overproduction was due to being uncertain that enough consistently good product would be the output of the process.” p.272 Basically demand forecasts and make to stock approach tends the firms to produce more within resulting overproduction.

4.1.3 Lead Time Compression

Lead time compression is another important component to provide customer requirements that is interrelated with demand uncertainty. In order to satisfy the customer, lead time reduction is crucial and customer avoids waiting for products accordingly. Lean terminology describes reduction of lead times through elimination of waste that does not add value process or service.

Value stream has also effect for lead time that depending on the material and information flow. By doing so value stream provides to see possibility of improving system design that resulted impact on lead time since waste is eliminated.

Quick response in this manner is essential to reduce lead times that JIT concept also occupies lead time compression to deliver the orders on time. Quick response enables supply chains to meet the customer demands for ever shorter lead times and synchronize the supply to meet the peaks and troughs of demand. (You and Grossmann, 2008) Moreover lead time reduction also contains strong supplier relationship between the members which implies increased responsiveness to the customers.

Inventory which is another waste issue also increases lead time and reduces the responsiveness. Nonetheless differentiated product delivery can be achieved through reduction of waiting time and holding low stock. Srinivasan (2004) mentions about 4th the lean supply chain principles in his book; “Maximize external variety while minimizing internal variety. Maintain an
inventory is an undifferentiated form as long as it is economically feasible to do so.” p.57 This strategy can be achievable due to the RAP principle which means “Keep in-process inventory as raw as possible.” (Srinivasan, 2004, p.56) This strategy is obtainable that products are based on forecast and differentiation of product is done postponed to the final assembly. This strategy reduces the lead time even though there is a high risk of forecast error.

Lead Time also has got a position from marketing perspective in lean philosophy as a market qualifier that reveals through elimination of waste and market position is upgraded accordingly. This situation is seen since the product type is consisted of commodities which correspond with lean philosophy.

4.1.4 Kanban

Sustainability of lean needs to have some functions such as continuous flow and replenishing the items hence kanban has an important role to provide these requirements that working as a signaling device. Hobbs (2003) states “The kanban methodology is a material presentation method designed to simplify material handling and inventory management.” p.5 Kanban replenishes the materials via signal hence they do not need to be filled up or allocated based on traditional forecast approach.

Basically kanban is used in Lean as usual that the demand variation is low and the product types are stable. On the other hand for demand uncertainty kanban can be used for differentiated products and initially kanbans are used in production of standard products that products are differentiated after withdrawn kanbans. The important issue is here the demand should be stable and predictable. Application of kanban can be achievable with push plan and pull execution. Naylor et. al (1999) mentions; “For example in one electronic firm the forecast is calculated yearly at the strategic level, monthly at production level but the final production is calculated weekly based upon the kanban.” p.113

Moreover, lead time is also has relationship with the kanban that in order to provide continuous replenishment via kanban, lead time should be reduced accordingly.

In this case, material flow becomes deterministic for whole system that in low demand uncertainty and high product complexity MRPII and kanban can be used together. Consumer products can be count in low uncertainty and high complexity products. Kruse (2002) states that “For consumer durables lean manufacturing is also highly relevant because, unlike fashion goods, price and quality are highly important in this market – both cornerstones of lean manufacturing.” p.20
MRPII takes a role for the entire production system including materials, finance and human relationship issues. According to Kruse (2002), “MRPII might be used to manage customer order entry, supplier communications and financial management but the operational planning and control demands are relatively low.” pp.19-20 For the consumer products, MRPII / ERP to manage the material flow, but it is normally supported by flow lines and kanbans.(Kruse, 2002)

4.1.5 Smooth Demand / Level Scheduling (Standardization)

In order to implement lean process in meeting with customer satisfaction, standardization emerges as a measurement tool for the system. Standardized work determines the whole harmonized system that reveals the continuous flow and eliminated waste for lean as well. To obtain continuous improvement in the system, processes should able to be standardized.

For demand uncertainty, lean manufacturing avoids changeable demands that can cause some unexpected situations such as increased inventory. In production level scheduling, items are produced in predictable demand with smaller variety of components. “This enables production to efficiently meet customer demands while avoiding batching and results in minimum inventories, capital costs, manpower, and production lead time through the whole value system.” (Lean Enterprise Institute, 2003, p. 24) “It is inappropriate to use a lean strategy in circumstances of high demand uncertainty because variability in demand volumes and variant mix make level scheduling infeasible.” (Waddington et al., 2002, p.14)

Level scheduling also provides strong relationship with suppliers that means unscheduled production causes to some disruptions such as Bullwhip effect. Even though working in low demand uncertainty, flexibility can be obtained among product volume and mix. Moreover inventory is reduced as a result of elimination of waste and the products are filled up for customer when they need them.

Nevertheless level scheduling plays a important role in lean and agile combination which reveals leagile. In Leagile approach demand is smoothed before decoupling point that lean process is applicable accordingly. The products are differentiated after decoupling point according to agile terminology. The point of product differentiation is at or downstream from decoupling point and the stock held at decoupling point acting as buffer between variable demand and a level production schedule. (Naylor et. al, 1999)
4.1.6 Virtual Corporation & Information Transparency / Material and Information Flow

Virtual Corporation and Information Transparency are cornerstones of the integrated supply chain that aiming to focus on customer demands or end user at the end of the chain. The necessity of quick responds to the customers within fully filled satisfaction is a key attribute for gaining marketing position and sustainability in the market. “To maximize competitive advantage all members within the supply chain should “seamlessly” work together to serve the end customer.” (Jones and Towill, 1997, p.137)

According to Lean philosophy synchronizing the production to the demand is essential that the takt time plays a key role to obtain this consistence accordingly. One of the waste issues is overproduction settles in information transparency and sharing manner that affects the cost and efficiency of system. Bullwhip effect also can be considerable due to lack of the information sharing and transparency. “The bullwhip effect teaches us that inventory grow inversely in the supply chain as a function of information that is shared among supply chain (vertical) partners. (Goldsby and Martichenko, 2005, p.182) “This relationship is reciprocal in nature; the less information is shared, the more inventories are created in the system.” (Goldsby and Martichenko, 2005, pp.182-183)

In spite of the necessity of integration between supply chains members, in reality there are some difficulties to implement wholly captured seamless supply chain due to the constraints. Goldsby and Martichenko (2005) mention accordingly “Seasonality of raw materials, economies of scale of manufacturing, electronic communication constraints, and uncertain demand from the customer are a few of the many constraints we face in order to reach seamless, waste –free supply chain”. (Goldsby and Martichenko, 2005, pp.182)

Lean terminology also interested in vertical integration and information sharing for reduction of inventory that depends on strong relationship. Basically starting with the customer point enables to go back to determine the requirements for supply chain while the exact customer demand is known. Since the problems are reduced by going upstream of the supply chain and system is getting closer towards to the optimized system.

Faisal et. al (2006) states regarding information and material flow that “Traditional supply chains does not focus on elimination of waste and so in certain situations particularly in those where the flow of the material and information from one echelon to another is disrupted it can still manage to deliver as here inventory would be buffer against those sudden disruptions albeit at higher cost.” p.886 Conversely in lean supply chain integration is essential. “With the integrated supply chain both the information and material flows will be simplified, streamlined and optimized reducing waste and lead times.” (Naylor et. al, 1999, p.110)
Integration of supply chains are classified in two ways for demand uncertainty perspective which are internal and external integration. In internal integration; Geary et. al (2002) mentions that “all work processes are integrated and the planning process reaches from the customer back to the supplier” p.57 while in external integration “The supply chain forms an extended enterprise. The organization has achieved integration with all suppliers and synchronized material flows. The focus is on customer.” (Geary et. al, 2002, p.57) From internal perspective, building seamless supply chain enables efficient value utilization within low cost level. Inventory levels are reduced that provides avoiding of obsolescence issue turning on increased efficiency and decreased cost levels in the system. From external perspective, “A company has predictable supply chain performance can more reliably serve the customer.” (Geary et. al, 2002, p.59) By doing so, costs are reduced; profitability and market share are increased. Accordingly figure 4.2 states;

Figure 4.2 - Internal and External Integration

4.1.7 Using market knowledge

In order to follow Lean terminology in terms of cost reduction, elimination of waste and increased efficiency perspective on the system, providing market knowledge and predictability of demand is essential. “If market knowledge is not exploited and the supply chain is to be made more responsive then the members of the supply chain run the risk of, for example, producing too wide a variety of products at short notice when there is insufficient demand to justify the extra cost.” (Naylor et. al, 1999, p.109)

Lean manufacturing focuses on smooth demand and the first priority occupies elimination of waste (muda). Moreover by elimination of waste minimizes the cost and increases the profit accordingly. In marketability, cost is determined as a market winner in Lean while quality, lead time and service level is described as a market qualifier. Nevertheless market qualifiers are determinants for gaining a position in market which implies competitiveness
while market winner (cost) emerges as an obligation. By doing so, in lean predictable demand is essential smoothly. In this manner cost reduction is achieved via physical costs which include all production, distribution and storage costs. (Jones et. al, 2000b)

4.1.8 Level of Automation

Level of automation reveals the firms velocity in volume of product with described product types. Basically automation captures essential factors that directly affect lean manufacturing terminology. Those are especially defined as lead time and elimination of waste. Besides automation causes waste which is considerable in lean concept. Waurzyniak (2009) states that “if something is on a conveyor system being transported from place to place, it is simply automation of waste.” p.67

Through automation level, lead time is affected due to the speed of process by affecting value stream throughout the supply chain. Determination of right level of automation is essential to meet customer demand since it entails to have an investment. By doing wholly automated system or making inappropriate automation arises some problems such as low uptime in terms of low efficiency.

Nevertheless overproduction and increased cost arises conversely to the lean in consequence of utilization of more people, more equipment and more material. Accordingly “A lean production system should be designed to flow, and automation should be selected after deciding how best to improve flow and fit into the flow. Lean is not manual but the right type of automation is required.” (Harris and Harris, 2008, p.32)

For demand uncertainty Morey (2008) mentions about level of automation; “In the most unpredictable assembly environment-low volumes, high product mix – manual assembly is usually the reasonable choice. Recouping investment in sophisticated automation would be difficult in this scenario.” p.117 In high volume and predictable product variety enhances efficiency and quality while reduces waste. Hence automation can be right choice in terms of increased process reliability and cutting cost comparison to manual solutions. According to Morey (2008)”The Rexroth Lean Production Matrix provides a basic framework for evaluating automation” p.115 in figure 4.3
In lean perspective high demand predictability and low demand variety in long-life cycle are crucial. Lean terminology has a tendency to incremental automation level in predictability since in high demand uncertainty and product variety implementation of automation becomes difficult due to the long changeover times and cost issue. Since changeover time increases while level of automation is upgraded compared to the manual process.

Consequently in high demand uncertainty, modification requirements in automation process are infeasible. Manual processes are tracked while product variety and volume are enlarged.
4.2 PARAMETERS OF CUSTOMER’S DEMAND UNCERTAINTY

Figure 4.4 Parameters of Customer’s demand uncertainty

4.2.1 Information

The most important parameter is Information; according to literature review it is found that information enrichment and sharing are among the keys attributes to manage uncertain situations. There are many ways to manage information sharing e.g. electronic data interchange (EDI) which results in quick response in whole supply chain. All stack holders in a supply chain can be able to see the required information from upstream to downstream on order to update their supply chains. Data capture from one source can be seen in a system like ERP etc. to others in entire supply chain.

4.2.1.1 Shared Call off Information

Nonetheless information delays decline system harmonization which causes problems between supply chain members since some unexpected results are accumulated such as increased stock levels in the system due to the bullwhip effect. That ambiguity effects demand uncertainty accordingly. Jones and Towill (1997) states the problem of information delays as mentioned according to source from Stalk and Hout in 1990:
“The underlying problem here is that once information ages, it loses value... old data causes amplifications, delay and overhead... The only way out of this disjointed supply system between companies to compress the information time so that the information circulating through system is fresh and meaningful.” p.138

4.2.1.2 Electronic Data Exchange (EDI)

EDI provides companies to electronically transmit data that used to be handled in paper form. (Levi et. al, 2008) Thus the data is transferred in standardized form between computer systems. For demand uncertainty conditions, it offers greatly improved information flow and also important tool within leading organizations in the fight to decrease lead times (Jones and Towill, 1997).

4.2.1.3 Quicker & More Accurate Response

In demand uncertainty condition, responding customer requirements take an important part for satisfaction that seamlessly information flow enables to manage it. In highly competitive situations, extended lead times arise since information flow has some distortions. It is also mentioned in Bullwhip effect that supply chain members have some disconnections due to the distorted information which is concluded increased stock levels that may be under high risk of obsolescence. Therefore exact data flow is essential which implies the reliability of information accordingly. On the other hand exact data flow enables either to gain competitive advantage in market or keeping integration of supply chain members that saving cost also considerable in this concept.

4.2.1.4 Rapid Response

Rapid Response is one of the important parameters of demand uncertainty since it enables and describes the firm’s condition in highly competitive marketing environment. ERP is stated as a rapid responsiveness tool to have adaption in the market changes both internal and external supply chains. ERP provides common infrastructure throughout the company that enables the entry point for internal use as well as for customers, suppliers and partners. (Levi et. al, 2008) On the other hand, e-collaboration tools such as ERP are widely used to manage complex product design and configuration in this manner. (Kruse, 2002) In rapid response; time saving is seen that tracking of the current and previous situation enables also lead time reduction since purchasing activities, inventory levels and production orders are balanced in this manner. Effective connections between both internal and external supply chains via ERP provides high customer service since higher fill rates and shorter lead times can be obtained accordingly.
4.2.2 Products

The products life cycle is also one of the key parameter in customer’s demand uncertainty context. Variants in different product should be in medium level because sudden or unpredictable change in market demand could reduce the possibility to sale semi-finished or finished products. According to literature review it is seen that product variety is low in lean context but is at its medium level when considers volatile market demand.

4.2.2.1 Product Life Cycle

Product life cycle is highly related with demand uncertainty conditions that short product life increases demand uncertainty. There are two concepts regarding forecasting and obsolescence issue at the beginning and end of the product life. When the new product is submitted in the market, there is a problem about prediction of quantity since there is no previous data. (Fisher et. al, 1994).Moreover there is risk at the end of the product life since product becomes obsolete if it is kept in inventory (Fisher et. al, 1994)

4.2.2.2 Product Variety

Product variety forces firms to response customer requirements that prediction of product becomes more difficult which also affects supply chain members. The cost can be increased due to the inventory levels which imply obsolescence issue hence production plans and orders needs to be more deterministic accordingly. On the other hand product variety forces the firms to have adaption in new process updates and also changes on materials can imply to search new suppliers for producers.

4.2.3 Contracts / Alliances

As mentioned in literature review, there are different kinds of supplier contracts, each of suitable in particular circumstances. These contracts and alliances / partnerships play an important role in customer’s demand uncertainty situations. In order to make ease in run new order according to sudden market changes or customer’s demand, supplier contracts plays a vital role for vendors or manufacturers to procure raw materials etc. and run their production accordingly. For instance, if after the procurement of raw material, the customer’s demand changes then the contracts could provide a way to return back raw material or some others ways to tackle the situation according to laid down contracts between two parties.
4.2.3.1 Responsive Supply Chain

Responsive Supply Chain is an important component to struggle sudden changes or fluctuations in demand where external harmony between supply chain members becomes essential in this manner. Basically, seamless flow of information needs to be obtained for upstream processes hence customer responsiveness can be achievable sufficiently. Information flow without distortion enables to get cost reduction since inventory levels are diminished which prevents the bullwhip effect. Filling rate is increased while holding cost is decreased accordingly. In this matter, contracts, alliances, and third-party logistic providers facilitate this aim to manage market changes.
4.3 **Parameters Relates Leagile Supply Chain & Customer’s Demand Uncertainty**

Figure 4.5 Parameters relates customer’s demand uncertainty & leagile supply chain

### 4.3.1 Vendor Managed Inventory

As mentioned analyzing point in sub section 4.2.3 that these contracts help to manage uncertain situations. In this context vendor managed inventory also a vital operations management approach. Since the importance of information can be denied in leagile supply chain network therefore the concept of Vendor Managed Inventory (VMI) played a vital role in this context. The organization provides information to their suppliers via EDI or ERP system etc regarding their future requirements and let the supplier decide to deliver the required amount within due time. As it is mentioned in literature review chapter that there several kinds of suppliers contracts available, so these contracts can make ease in creating a risk sharing environment in while supply chain. VMI provided more satisfied customers because whole supply chain contributes and shares information. It also provides advantage to all stack holders in whole supply chain in terms of reduction of cost i.e., both planning and ordering and all information is visible for all.

### 4.3.2 Service Level as Customers Driver

According to literature review, in leagile supply chain, services works exactly in the situation where demand is uncertain. It is found that while developing market strategy, service level considered being market winner. However, as mentioned in literature review that availability and cost are customer’s drivers in agile and lean supply chain respectively. Here the question may rise what does mean by service level? It could be to meet customer demand
as quick as possible, it could be to provide best quality, world class products, it could be to provide after sales services etc. But there is another factor which should be take into consideration while dealing with uncertainty i.e., capacity constrain. Since the production people are always wanted to meet the required targets on due time provided by production planning and control department (PP&C) but due to capacity constrains it might cause delay in delivery of the specific part within provided schedule. So in order to minimize the risk of late part delivery safety lead time calculation must be done.

4.3.3 Products according to Customers

As mentioned in literature review regarding leagile supply chain that products should be made according to customers demand within its specified standards and specifications. When the customer’s demand is uncertain products design may also need to be reconsidered several times. With the passage of time the product sales varies. If the product follows the forecasting demand then at least it follows its life cycle which includes different stages. But on the other hand if the product does not fulfill the predicted demand schedule than the management moves towards rapid strategic product development methods, which help to provide the data regarding the current trends in the markets according to the customer’s requirements.

4.3.4 Information Enrichment

Information enrichment has many dimensions which kind of information an organization wants to share throughout the supply chain. Information enrichment is based on the events happens from upstream to downstream supply chain. Since information follows in whole supply chain, a slight standard deviation on retailer side can make a huge standard deviation on manufacturing end. This implies that the quality and quantity of information matters in supply chain network.

4.3.5 Volatile and Unpredictable Demand

When there is an unpredictable demand situation that implies surely in uncertain position. According to literature review leagile supply chain is best suitable in such conditions using decoupling point.

4.3.6 Robustness

Under uncertain situations if a system has ability to sustain or withstand unpredictable changes in circumstances then there may be little risk of system collapse. According to literature review, a desirable attribute of leagile supply chain is robustness. Because it provides the best possible alternative decision in order to overcome uncertain situation while taking into consideration the
risk level and degree of satisfaction. Certainly the degree of uncertainty determines robustness in a system.
5 DISCUSSION, CONCLUSION & FUTURE RESEARCH

5.1 DISCUSSION

The role of lean philosophy in today’s manufacturing world cannot be denied, but the engineers have been forced by the competitive world to widen the scope by adopting the agile philosophy. These two philosophies are so useful but any one of them cannot provide a complete solution in customer’s demand uncertainty situations. Therefore, there was a need to combine or merge these two approaches with the help of decoupling point. This decoupling point is flexible in order to provide a solution to the engineers especially in the situation like uncertainty. In addition with the parameters explained in the last chapter here another management perspective is drawn for discussion, since the strategic use of decoupling point in vital in agile supply chain in management context. As we know that in demand uncertainty situations organizations also face financial challenges and the management might be forced to reduce the man power. The management starts to put all focus on sales activities, rationalizing their business and re-organizing the work force. In this context there is always need to establish a flexible organizational behavior which includes many aspects. Here some of them are discussed in order extend the scope for developing of the framework. For instance managers should be able to understand the facts with logic, rational arguments and persuasive reasoning. Managers should be highly verbal and articulates in order to persuade others and their arguments should be structured in order to follow others their logic. This managerial behavior is very useful especially in reviewing the market strategies and while dealing with facts and findings. The managers as leaders under uncertain situations must participate, support, share information and also move to decision making down into the organization. They must believe in people and communicate what they belief. Cooperation and collaboration are also key characteristics which must present in a manger because a manager as a leader always concentrate on what is wrong and how to prevent from it; they debate with people and let them ask questions. In this way it becomes easy for their subordinates to contribute. As we are very well aware of lean philosophy which stresses in top management support and employers empowerment, the above leadership qualities in managers are directly and positively relates with lean philosophy especially when the challenges such as are financial, man power reduction, sales activities concentration, rationalizing of business and work force re-organization are being faced.

In situations where customer’s demand is uncertain management must think about the motivational level in their employees. For instance, (i) only a motivated manager can motivate his sub ordinates. (ii) It is important for management to select people for certain situations who are already motivated.
During discussion with employees in uncertain situations it is important for a manager to have conversation with each individual. (iv) When management set challenging and realistic targets with those who held responsible to carry them out, it helps for both management and employees in order to motivate them. (v) After overcoming the uncertain situation it is also important to get feedback in order to whether the direction was right at the right pace. (vi) Mutual feedback and constructive disagreement could be helpful in creating a motivating environment. (vii) After overcoming the uncertain situation if management provides fair rewards then it would help for professional development and personal growth. (viii) Appreciation and recognition are keys for establishing long term commitment. (Adair, 2006) In the lean context this behavior helps in establishing an organizational culture where an individual also try of fix the problems on first spot. These problems do not only mean the problems at production side i.e., internal but could also mean to fix the problems which can happen as a result of unpredictable market changes i.e., external.

Although customer’s demand uncertainty is external problem in a way that fluctuation in customers’ orders happen due to external factors. In order to overcome and tackle the uncertain situation there is always need to develop a team, which should work in stages. For example; in first stage managers should choose members of the team and sets goals, objectives, roles of each team member etc., in second stage brain storming should be done and give importance to the knowledge of each member, in third stage team members should form the procedures and sets the certain rules, and at last stage the team should focus of achievement of particles task. At that stage it is important to us fully use the team’s resources. Osland et al., (2001). In order to follow the overall company philosophy, the lean philosophy stresses in developing exceptional people and teams. At many stages mangers need to take decisions for example in leagile supply chain while making decision in positioning of the decoupling point, it is important to follow rational decision making process, which may includes the following stages: (i) It is important to describe the problem and related advantages, (ii) what would be the decision criteria and allocation of weights to each criteria, (iii) evaluation of alternatives, (iv) decision implementation and evaluation. (Luzzi,2001)

It is worthwhile noting that in order to built trust between an organization and its supplier, effective communication has a key role, it directly affects the trust level. The trust level can increase the level of satisfaction. It is also important to know the strategic features of supply chain in an organization. The level of integration determines coordination and cooperation with in a system, the mutual dependence of supplier and customers also leads to reduction in logistics cost. Lean philosophy stresses just in time production but on the same time if we consider average cost per unit product which can be decrease when sales of the product increase for a certain period of time.
Under demand uncertain situations economy of scale helps to overcome depression cost.

Appendix I provide a list of questions which are related with demand uncertainty, lean manufacturing and agile manufacturing. The questionnaire is complied for internal managers / executives who are intended to evaluate the plant. Appendix II is build in support of this questionnaire. The categories regarding customer’s demand uncertainty, lean manufacturing and agile are manufacturing are mentioned in appendix II. Each question is marked by related categories. The last three columns point out whether the questions related with lean or agile or demand uncertainty or all.
5.2 CONCLUSION

The following framework helps organizations in customer’s demand uncertainty situations. That framework is described in four categories such as: Information systems, Suppliers’ contracts / alliances, Manufacturers (having leagile system) and marketing issues. Each category will be explained here in detail.

<table>
<thead>
<tr>
<th>Information System</th>
<th>Suppliers Contracts</th>
<th>Manufacturers (Leagile Systems)</th>
<th>Marketing</th>
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<tbody>
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<td></td>
<td></td>
<td>Strategies</td>
<td>People</td>
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<td></td>
<td></td>
<td>Robustness</td>
<td>Make or Buy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VMI</td>
<td>Capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ERP</td>
<td>Employee Compensation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EDI</td>
<td>Logistic Response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sales- Rebate</td>
<td>Alliances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pay Back</td>
<td>Employee Empowerment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost Sharing</td>
<td>Economy of scale</td>
</tr>
</tbody>
</table>

Since the information sharing is vital in the situation where there is uncertain situation therefore information system is put in first column in order to be sure that the organization who will follow this framework must know the importance of information sharing. Exploring the information through ERP is also important, after that the analysis of that particular information by management must be done. Here it is desired to highlight the required behavior of the management in the context of customer’s demand uncertainty. Managers must have full authorities to take decisions instantly by using their experience. Besides that, the knowledge of risk management is also very important according to this framework.

In that framework the manufacturer must have contacts with the suppliers. These contracts or alliances depend upon the particular situations and industry but in general it is highlighted six common contracts which can be implemented in any organization.

Marketing issues are divided in two categories such as strategies and components / elements. In the situation where customer’s demand is uncertain, an organization must re-consider their marketing strategies several times, which must depend upon the information they received and shared with other stack holder. As we know that in the leagile system where response to customer is crucial, that framework also stressed towards the
accessibility and availability of manufacturer to customers. This framework provides a guideline in order to make decisions in uncertain market situations. A manufacturer is the most important part of this framework. As different literatures are read regarding lean and agile approaches by researchers, the conclusion is reached that in the situation where customer’s demand uncertainty is present these two approaches should be combined together. In literature review chapter, the concepts are already explained related with leagile system. This framework mentions three categories in which leagile system must be implemented in order to deal with external uncertainty. Decoupling is vital in leagile system and we recommend flexible decoupling point.

Three assessment tables are made which are shown in appendix III, IV and V. These tables are designed for external consultants who intend to evaluate the plant performance in context of demand uncertainty, leaness and agile. Appendix III refers to assessment table regarding demand uncertainty. Categories of demand uncertainty are mentioned in first column and remaining five columns are made in order to allot the grades. For instance full certainty is assigned 5 grades and full uncertainty is assigned 1 grade so on and so forth under each category. Grade 60 represents the full certainty in each category, Grade 12 represents the full uncertainty in each category and grade 36 represents normal situation.

Appendix IV refers to assessment table regarding lean manufacturing. Categories of lean manufacturing are mentioned in first column and remaining five columns are made in order to allot the grades. For instance too low leanness is assigned 1 grade and too high leanness is assigned 5 grade so on and so forth under each category. Grade 60 represents the too high leanness in each category, Grade 12 represents the too low in each category and grade 36 represents normal situation. Appendix V has same logic as Appendix IV, which has already explained above.

For instance as a consultant, the interviews can be conducted with the managers in order to ask questions in a plant having lean manufacturing system. After getting the answers (according to our questionnaire, see appendix 1) the assessment tables can be filled (see appendix III, IV, V). These assessment tables provide an evaluation regarding three different perspectives i.e. demand uncertainty, lean and agile approaches.

In order to assess the categories the following formula was created:

\[
\text{Categories of DU}(x), \text{LM}(y) \text{ and AM(}z) = T \text{ (for instance DU7 is touched 6 times among 32 questions)}
\]
\[
\text{Number of Positive Answers (+)} = t
\]
\[
\text{Negative Answers (-)} = T-t
\]
The relationship between Lean manufacturing & customer’s demand uncertainty

Level of (Demand Certainty, Leanness and Agility) = \( \frac{t}{T} \)

- 0-0.20 = (Full Uncertainty, Too Low Lean, Too Low Agile)
- 0.21-0.40 = (Uncertainty, Low Lean, Low Agile)
- 0.41-0.60 = (Normal)
- 0.61-0.80 = (Certainty, High Lean, High Agile)
- 0.81-1 = (Full Certainty, Too High Lean, Too High Agile)

For instance:
Let’s assume we got 4 positive answers and 2 negative answers regarding DU7 = 6

Number of Touch Regarding DU7 = 6
Positive Answers (+) = 4
Negative Answers (-) = 2
Level of Demand Certainty = \( \frac{4}{6} = 0.66 \)

So, \( 0.66 \) is between (0.61-0.80) Grade = 4 for DU7

Finally this framework is recommended to the managers so they can implement leagile system in their whole supply chain.
5.3 Future Research

This study was started in context of external factors regarding manufacturing which relates with customer’s demand uncertainty situations. Researchers focused in this framework leagile supply chain. It is believed that this master thesis can lead toward for other thesis because there is a need to have some case studies in different manufacturing industries in order to further analyze and prepare more concrete framework for uncertain situation. The scope of the further research case can be extended for both external and external uncertainty, which as a result can provide a better solution in future competitive world.
6 REFERENCES


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Waddington, T., Childerhouse, P., and Towill, D. (2001-02) Engineer your supply chain to cope with demand uncertainties MIOM Forward Vision –LSDG University of Cardiff

Waurzyniak, P. (2009) Lean Automation- Combining lean manufacturing tools with the right automation systems can boost productivity- Manufacturing Engineering; Feb 2009; 142,2; ABI/INFORM Global


<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Answers</th>
<th>Categories</th>
<th>Demand Uncertainty (DU)</th>
<th>Lean (LM)</th>
<th>Agile (AM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Does the firm production strategy depend on pull or push strategy?</td>
<td>o Yes, pull strategy</td>
<td>DU1-DU6-DU11-LM1-LM4-LM5-AM3-AM5-AM11-AM12</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>o No, push strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Does the firm have collaboration with supplier in case of contracts? If</td>
<td>o Yes, ……… Contract</td>
<td>DU7-LM12-AM3</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>yes what kind of contracts is the firm implementing?</td>
<td>o No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Does the firm sufficient to fulfill the customer service levels on agreed</td>
<td>o Yes, ……… % fullfilment rate</td>
<td>DU8-LM1-AM1-AM2</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>time? If yes how many percent is the firm able to do that?</td>
<td>o No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Does the firm have some strategies to balance production schedule in</td>
<td>o Yes, ……… (Make-to-order, Make-</td>
<td>DU6-LM5-LM10-AM5-AM11-AM12</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>terms of pull or push strategy? If so, which one is closer in terms of</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>make to order and make to stock?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) How often does the firm get some complaints or problems regarding the</td>
<td>o Yes</td>
<td>DU5</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>product or service quality? If you were a customer, would you buy this</td>
<td>o No, Return of product rate is ……… %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>product?</td>
<td>on every (day, month, year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td>Codes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 6. What is the first priority of contact with customers? Does the firm offer to give a service to them or they initially contact with firm to take their service? | o Yes, firm offers to give a service directlly.  
  o No, they should contact initially with firm. | DU7-DU10        |
| 7. Does the firm have some organizational responsibility in management level to solve the problems either internally in work shop or externally with supply chains? If so, how do you manage it? | o Yes  
  o Individual and Organizational Motivation  
  o Decision Making  
  o Authority  
  o Experiences  
  o No | DU9             |
| 8. Does the firm integrate all work level to make decision or empowering them to solve the problems and continuous improvements? | o Yes we do  
  o No, we do not | DU9-LM6-LM7-AM6 |
| 9. Do the firm relationships depend on long-term or short term agreement with customers? | o Yes, Long Term  
  o No, Short Term | DU7-DU10-LM12  |
| 10. Does the firm have any delays on shipment to the customer if so in which level? | o Yes.......rarely sometimes, often  
  o No, delivering on time is essential | DU10-LM1-AM1-AM2 |
| 11. What is the first priority of firm that focuses on? | o Cost Reduction  
  o Responsiveness to Customer | LM3-AM2         |
| 12. Does the firm strongly aim to avoid waste or you can tolerate it on? | o No tolerance  
  o Not first priority, response to | LM2-AM2         |
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Code</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the firm have virtual systems to track the faults or replenishment of materials?</td>
<td>Yes we do</td>
<td>DU2-DU3-LM1</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, we do not</td>
<td>DU2-DU3-LM1</td>
<td>X</td>
</tr>
<tr>
<td>Does the firm share the personnel with suppliers?</td>
<td>Yes we do</td>
<td>DU7-LM12-AM9-AM10</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, we do not</td>
<td>DU7-LM12-AM9-AM10</td>
<td>X</td>
</tr>
<tr>
<td>Does the firm have outsourcing activities?</td>
<td>Yes we do</td>
<td>DU7-LM11-LM12-AM9-AM10</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, we do not</td>
<td>DU7-LM11-LM12-AM9-AM10</td>
<td>X</td>
</tr>
<tr>
<td>What is the firm’s strategy regarding keeping stocks that in which stage stage stocks are held?</td>
<td>Fully finished goods</td>
<td>DU2-DU3-DU4-AM11-AM12</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Non finished parts</td>
<td>DU2-DU3-DU4-AM11-AM12</td>
<td>X</td>
</tr>
<tr>
<td>Does the firm have advanced information technologies both internal and external perspective?</td>
<td>Yes, ....... (such as ERP,MRP,EDI)</td>
<td>DU1-AM3-AM5-AM6</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>DU1-AM3-AM6</td>
<td>X</td>
</tr>
<tr>
<td>Is the firm able to see and control retailer's inventory for efficient supply?</td>
<td>Yes we do</td>
<td>DU1-AM3-AM6</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, we do not</td>
<td>DU1-AM3-AM6</td>
<td>X</td>
</tr>
<tr>
<td>Is there any distortion and delays in data while it flows throughout supply chain?</td>
<td>Yes</td>
<td>DU1-LM9-LM11-AM7-AM11-AM12</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, it flows without distortion and delay</td>
<td>DU1-LM9-LM11-AM7-AM11-AM12</td>
<td>X</td>
</tr>
<tr>
<td>Does the firm have any strategy to deal products on single handling unit to customers?</td>
<td>Yes we do</td>
<td>DU2-LM2-LM3-LM11-AM10</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No, we do not</td>
<td>DU2-LM2-LM3-LM11-AM10</td>
<td>X</td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td>Codes</td>
<td>DU7-DU8-LM12-AM9</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>21) Does the firm have other supplier services which provide in terms of</td>
<td>- Yes we do</td>
<td>DU7-DU8-LM12-AM9</td>
<td>X</td>
</tr>
<tr>
<td>consultancy transportation and management skills to the firm?</td>
<td>- No, we do not</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22) What is the strategy of process in shop floor?</td>
<td>- Standardization of process is essential</td>
<td>DU12-LM6-AM2-AM8</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- It can be changeable according to market conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Totally manual</td>
<td>LM8</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Manual and Automation mixed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Totally automated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23) Does the firm utilize automated system, if so in which level?</td>
<td>- Yes, it is predictable</td>
<td>DU2-DU3-LM10-AM5</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- No, it is unpredictable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24) Does the firm have predictable demand on products types?</td>
<td>- Modular Architecture</td>
<td>DU2-DU3-DU4-LM6-AM5</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Integral Architecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25) If you categorize your product which architecture is much closer to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>your product?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26) Does the firm have predictable demand on products volume?</td>
<td>- Yes, it is predictable</td>
<td>DU4-LM10-AM5-AM11-AM12</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- No, it is unpredictable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27) Does the firm have any measurable goals regarding customer</td>
<td>- Yes</td>
<td>DU8-DU10-LM7</td>
<td>X</td>
</tr>
<tr>
<td>demand frequency, i.e. lead time?</td>
<td>- No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------------</td>
<td>---------------</td>
<td>------</td>
</tr>
<tr>
<td>28) Does the firm follow any strategy for product flow from one</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>operation to another one, i.e. FIFO?</td>
<td>Yes/No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29) How the processes can be described according to stability or variety</td>
<td>Intensive process</td>
<td>LM7</td>
<td>X</td>
</tr>
<tr>
<td>of market conditions?</td>
<td>Less intensive,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>more single and simplified process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30) Does the firm have capability to adapt sudden changes via</td>
<td>Yes/No we do</td>
<td>Du12-Am4-Am8-Am10-Am5</td>
<td>X</td>
</tr>
<tr>
<td>interpretation of knowledge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31) Does the firm have flexibility on processes which can be converted</td>
<td>Yes/No we do</td>
<td>Du12-Am4-Am8-Am10-Am5</td>
<td>X</td>
</tr>
<tr>
<td>across market conditions?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32) Does the firm allocate any capacity for stock across demand</td>
<td>Yes/No we do</td>
<td>Du12-Am4-Am8-Am10-Am5</td>
<td>X</td>
</tr>
<tr>
<td>fluctuations?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix II

Categories according to Customer Demand Uncertainty (DU)

DU1) Virtual Supply Chain

In uncertainty condition, virtual supply chain enables the clear relationship between supply members that is concluded effective and timely efficient system for external perspective. For instance the data sharing provides shipment of goods within minimized lead time via information technology which also implies the reduced inventory level and so on. Thereby whole integration between supplier, manufacturer and distributor can be obtained, cost and uncertainty are diminished.

DU2) Product Diversity

Product diversity forces the firms to response to the customers that robust solutions should be accomplished such as scheduling system according to frequency of product types. That reveals the uncertainty of product types which should be taken under the control.

DU3) Product Life-Cycle

Product Life Cycle is also related with demand uncertainty while life cycle is shortened, demand uncertainty increases accordingly.

DU4) Demand Volume

Demand Volume can be an issue of demand uncertainty condition while product diversity and short product life cycles appear that causes under level of production from demand which implies shortage costs or exceed stock level which states obsolescence cost.

DU5) Product Quality and Reliability

Quality and reliability issues for product perspective are determinant factor of customer satisfaction. Increased scrap rates and defects on products can give negative effect for customer which can cause uncertainty in demand. Hence in order to provide customer requirements from concrete perspective; quality standards should be fulfilled that increases the loyalty for customer.

DU6) Production Schedule (Make-to-order or Make-to-stock)

For certainty or uncertainty conditions the firms can tend to plan their production schedules such as make to order or make to stock. If the master production plan is based on demand forecast and this forecast has a big confidence, make to stock approach is applicable with high demand variety while make to order approach is appropriate for customized products with low demand variety.
THE RELATIONSHIP BETWEEN LEAN MANUFACTURING & CUSTOMER’S DEMAND UNCERTAINTY

DU7) Contracts with Suppliers

In uncertain demand conditions, supply contracts can be determinant of sustainability that provides reinforced relationships between buyer and supplier. Contracts provide strong collaborations between supply chain members that material and product flow become more robust and the uncertainty is reduced even though some players can have extra cost.

DU8) Accomplishing Service Level

Fulfilled service reveals the health of whole system that important thing is in this manner compatibility between supply chain members. For instance unstable customer lead times can prevent a goal of 100% filling rate due to the fluctuation of demands which states uncertainty. In order to diminish uncertainty, service level can be visual measurement tool therefore certain goals and improvements can be accomplished.

DU9) Leadership

In uncertain conditions, in order to take decisions, some initiatives could be necessity such as leadership that can be great tool to deal ambiguity in system dynamics. Nevertheless in high uncertainty, some of the players should use their initiative to manage that this initiative could consist of experience, authority, empowerment of employee as well. In uncertain demand conditions, for instance senior manager can take a responsibility to overcome insufficient demand amount such as assigning extra shift.

DU10) Adherence to Customer

Adherence to Customer is important to gain customer trust. Especially adherence reveals the relationship whether long or short term. In this manner, under demand uncertainty customers can tend to look for other competitors due to obtain their service i.e. in lower costs, on desired delivery time and so on. Hence capturing certainty mitigates this disturbances and increases adherence accordingly.

DU11) Level of Capacity Utilization

Capacity Utilization in demand uncertainty needs to be considerable. The strategy can be either fully utilization of capacity or some of the capacity can be kept as a buffer while demand fluctuations are on high level. Moreover outsourcing activities can be applicable to expand the capacity.

DU12) Process Flexibility

Process flexibility describes the firms’ adaptability in unexpected demand fluctuations that may enable to expand market position due to effective responsiveness to the customer. On the other hand excessive flexibility causes high investment costs and excessive variability on products trigger obsolescence issue accordingly. Thereby simple and consistent flexibility results on high efficiency and profitability.
Categories according to Lean Manufacturing (LM)

LM1) Delivery on Time

In order to respond customer demands effectively, delivery on time describes the firm’s sustainability and market position in the market that is corresponded with JIT concept which means neither early nor late.

LM2) Elimination of waste

While the firms are aware of the unnecessary activities either internal or external environment, they are able to reduce product cost and increasingly productivity and efficiency are obtained. Especially overproduction and high inventory could be essential in demand uncertainty manner.

LM3) Reduction on Cost

Reduction on cost is crucial in lean concept that provides to firms having market winning.

LM4) Signalized Virtual Systems

Signalized Virtual Systems implies some necessary activities as guidelines with simple tools to the workers that can either be in unexpected breakdowns or replenishment of materials, such as kanban and andon calls. This system provides clues to workers, time saving, high efficiency and productivity for the systems.

LM5) Pull Execution

Pull execution is a heart of the lean concept that the delivery on demand is carried out an agreed lead times with customer which reveals directly real demand. In this manner product volume is high and customized.

LM6) Level Scheduling (Standardization)

Standardization is another point in lean process that the part goes in planned environment with low variety. This enables to firms to gain fastness, reduction on stock levels, lead times and low necessity of human in the system. Employee empowerment is also important factor for standardization of work.

LM7) Continuous (one-piece) Flow

Continuous flow mentions the flow of product within reduced work-in process, waiting time and distances. This concept is related with takt time in terms of customer demand frequency and FIFO (First in-first out) that are important for accomplishment of continuous flow.
THE RELATIONSHIP BETWEEN LEAN MANUFACTURING & CUSTOMER’S DEMAND UNCERTAINTY

LM8) Level of Automation

Automation level is used to increase efficiency; to reach agreed lead time and firms’ velocity in product volume within describe product type. Since right level of automation enables to meet customer demands that high uptime level becomes essential to prevent cost enhancement.

LM9) Material and Information Flow

Material and Information Flow is crucial in lean terminology since it presents reduced wastes, lead times with simplified flow. In this manner internal and external integration should be obtained.

LM10) Predictability of Demand and Product Characteristics

In lean philosophy, predictability of demand is essential that product types depend on long-life cycle since these characteristics are important in order to get reduced cost level. Functional products are preferred that consist of standard based.

LM11) Postponement Strategy for Lean Perspective (Upstream Process from Decoupling Point)

Postponement strategy is based on upstream process from decoupling point that the standardization, elimination of waste and cost reduction is essential in this concept. Basically postponement strategy determines how much of the product is standardized that postponement of product differentiation is obtained smoothly since efficiency is obtained from lean perspective. In this manner push plan is implemented till decoupling point that accuracy of forecasting is crucial.

LM12) Partnerships and Alliances with Supplier

Lean Manufacturing firms desire high partnerships and collaborations with their suppliers in order to get cost reduction, product and process improvements and enhanced flexibility together since long-term agreements are seen in lean i.e. supplier and manufacturer collaboration is the center of the responding customer requirements which is the way of the sustainability of whole supply chains.

Categories according to Agile Manufacturing (AM)

AM1) Customer Satisfaction (lead time and availability)

Basically agile concept is based on availability to the customer since the first priority is adoption of the changeable demand conditions to satisfy customers without any delays or increased lead time.

AM2) Quick Response (Quick Responsiveness to customer)

Agile paradigm intends to carry out demand flexibility which is resulted on quick responsiveness and continuous replenishment to the customer on requested time that represents reduced cost levels in terms of facilitating reduced stock levels and obsolescence issues also preventing absence of products.
AM3) Software Systems for E-Collaboration

Agile manufacturing depends on the integration of enterprises that demand and market changes are adopted which take an important part for demand uncertainty. For instance; software systems is used to share information throughout whole enterprise and updates are recognized quickly via e-collaboration. (EDI, ERP, Internet, MRPII) Information is shared between supply chain members according to predefined contracts such as fixed price contracts.

AM4) Robustness

In Agile concept, the necessity of adaptation to volatility of demand in volume and variety forces firms to strive in difficulty that the firms intends to have intensive process rather than small and single process. Since it implies the robustness of the system that lean philosophy does not strongly aim to focus on robustness due to demand stability and level scheduling is essential accordingly.

AM5) Unpredictability of Demand

In Agile manufacturing, volatility of demand is essential since volume and variety are seen that product types are based on short-life cycle according to market changes. Innovative products such as fashionable products are preferred in this concept.

AM6) Knowledge Based Enterprise

Integration is the crucial point between supply chain members in order to response customer needs consistently since knowledge plays a key role to accomplish some characteristics which depend on experiences of human in organization, historical data’s, reports and so forth. Therefore well educated, right skilled human capability becomes determinant of knowledge perspective in agile.

AM7) Postponement Strategy (Downstream Process from Decoupling Point)

In Agile, postponement strategy is based on downstream process from decoupling point that reveals the second stage after lean process. Postponement strategy for agile concept shows that variety of product is started after decoupling point since the strategy becomes demand driven and based on pull system hence effectiveness is obtained accordingly.

AM8) Mass Customization

Incremental variety and volume on product and responsiveness to customer demand make agile manufacturing system in mass customization based that flexibility in process is obtained also product modularity should be considered in this concept. For instance for car industries, most of the parts depend on the same components (mass) however those are differed in models (customization)

AM9) Process Integration

In Agile concept flexibility in manufacturing is essential that process integration should be obtained both internally and externally. Internal perspective means i.e. rapid reconfiguration in production process while external perspective implies
collaboration between buyers and suppliers such as information sharing or joining product development project together.

**AM10) Reduction of complexity**

Complexity forces agile manufactures to be engaged in high variety that reduction in complexity enables the firms to enhance agility since this attempt namely becoming more standardize conditions increases cost reduction and organizational structures i.e. cross functional working.

**AM11) Stock policy**

In Agile manufacturing, the purpose of stock policy is to keep semi-products or uncompleted parts rather than fully finished goods.

**AM12) Protective Capacity**

Agile manufacturing firms use protective capacity in order to struggle to demand fluctuations that fast response to customer is obtained in uncertain demand conditions. In contrast lean manufacturers avoid having protective capacity that level scheduling is fundamental in this manner.
### Appendix III

<table>
<thead>
<tr>
<th>Categories</th>
<th>Full Uncertainty</th>
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<td>Demand Volume</td>
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<td>Product Quality and Reliability</td>
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<td>Contracts with Suppliers</td>
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### Appendix IV

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<td>Continuous (one-piece) Flow</td>
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### Appendix V

#### Assessment Table Agile Manufacturing

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<td>Software Systems for E-Collaboration</td>
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<td>Mass Customization</td>
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<td>Stock policy</td>
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