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A LEAN LOGISTICS ASSESSMENT TOOL FOR SMEs IN THE MANUFACTURING SECTOR

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A LEAN LOGISTICS ASSESSMENT TOOL FOR SMEs IN THE MANUFACTURING SECTOR

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This thesis is dedicated to my whole family, especially 3 people. To my mom, who has always believed in me. To my dad, for teaching me that I have to keep trying no matter what, and to Lucio who has taught me to believe in myself and appreciate the little things in life.

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Ever grateful, ever true! Boiler up!

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ABSTRACT

Sanchez Ramirez, Diana Lorena. M.S.I.T., Purdue University, May 2014. A Lean Logistics Self-Assessment Tool for SMEs in the Manufacturing Sector. Major Professor: Edie Schmidt.

This study developed an assessment tool to rate the maturity of the current and desired states of lean logistics operations in small and medium enterprises. The tool consists of 48 best practices classified into 8 critical factors: Inventory, Transportation, Administration, Information Systems, Warehouse, Forecasting, Packaging and Supplier Network. Each of the best practices and critical factors were identified throughout a thorough literature review and comparative analysis between authors to define commonalities among them. Using gap analysis; this tool results in a SWOT matrix providing a roadmap for lean implementation. The resulting model was evaluated by subject matter experts in different criteria, including: clarity, content accuracy, relevance, content validity, avoidance of bias, appropriateness of language, and clarity of instructions. The evaluations resulted in some minor corrections but not important changes to the content were incorporated as result of these evaluations. This research project represents the initial steps to developing a self-assessment tool; additional work is required before the tool could actually be used for managers in SMEs.

CHAPTER 1. INTRODUCTION

This chapter describes the significance, motivation and purpose for this study. The chapter presents the assumptions, limitations and delimitations under which this research is conducted.

1.1 Background

Lean Manufacturing is a management strategy that has helped many companies to thrive under rough competitive conditions. In general, lean techniques reduce costs and increase productivity by eliminating waste within the manufacturing environment (Wanitwattanakosol & Sopadang, 2012). The application of this technique in other environments has attracted the interest of many researchers as well as practitioners (Sternberg, 2013). However, the adaptation of lean techniques in logistics operations in small and medium companies is an area that needs further research. This study provides an assessment tool to assess lean logistics best practices in small and medium enterprises (SMEs) in the manufacturing sector.

1.2 Significance

Managing logistics operations is vital for companies' profitability and performance. Successful logistics operations require the creation of strategies and techniques that support manager's decision making process of the issues they face in practice. The application of modern management techniques, including lean logistics, could help managers to face these challenges successfully. According to Martichenko (2013), some of the benefits that result from lean logistics implementation are: higher customer satisfaction due to incremented fill rate, higher visibility in the supply chain and better performance measurement, higher inventory turns and reduced inventory levels, cost reduction in warehousing and transportation, better supplier performance, and supply chain total cost reduction.

Many of the studies on lean systems and lean logistics have been generated through research in large enterprises (LEs) with global operations such as the automobile industries. In recent years, SMEs started to face challenges in competition that have prompted them to adopt lean to enhance their competitiveness (Zhou, 2012). However, there is little evidence in publications about how the lean practices were implemented in this type of companies and what factors contributed to the success or failure of the lean implementation (Wanitwattanakosol & Sopadang, 2012). This situation limits the possibility of creating a broadly applicable lean logistics theory (Karlsson & Åhlström, 1997) by excluding the SMEs perspective.

In general, LEs have organizational structures that promote specialization including separately organized supply chain management (SCM) functions (Vaaland & Heide, 2007). On the other hand, SMEs are challenged by resource limitations, which results in the inability to implement SCM techniques to the full extent. Approaching lean logistics from the SMEs perspective could generate a better understanding of the challenges and risks these firms face when competing with LEs in a global economy. Recognizing their own strengths, weaknesses, opportunities and threats would be useful in the creation of a lean logistics roadmap or implementation plan that would help SMEs recognize their current state and visualize the desired state that they expect to achieve.

The insights contained in this study will help researchers and companies who have struggled analyzing and implementing lean logistics in SMEs. Additionally, this study contributes to bridge the gap that has kept those firms relegated from the benefits of lean, providing a better understanding of key factors, issues, and potential solutions to lean logistics.

1.3 Statement of Purpose

This exploratory study develops an assessment tool to rate the maturity of the current and desired states of lean logistics operations in a company. Then, the model proposes a SWOT matrix based on gap analysis that acts as a roadmap for continuous improvement. The model provides a structured and organized approach to the self-assessment process and acts as a tool to assist the identification of risks and critical barriers to implementing lean logistics.

1.4 Problem Statement

Lean Manufacturing originated in the Japanese automobile manufacturer, Toyota, in the 1970s. The core of this philosophy is to create value for the customer with less investment; in other words, reduce any form of waste while meeting customer expectations.

Table 1.1 shows the seven forms of waste that lean thinking tries to eliminate.

Although many US major companies, including Danaher Corporation and Harley-Davidson, have implemented lean; the results obtained can be ambiguous and sometimes unexpected (Wilson & Roy, 2009). Many companies have encountered difficulties in the attempt to apply lean, including absence of direction and planning and inadequate project sequencing (Bhasin & Burcher, 2006).

Table 1.1 Seven forms of waste

Waste
✓ Overproduction
✓ Time on hand (waiting)
✓ Transportation
✓ Processing
✓ Stock on hand (inventory)
✓ Movement
✓ Making defective products

Since business processes vary from one firm to another, each company needs to evaluate its own processes and implement lean in a customized manner. Even though this philosophy originated in the manufacturing

environment, it has gained the attention of other sectors including the service industry (Sternberg, 2013). This is an evidence of the ability of this philosophy to adapt to different conditions. Adaptability is an advantage because the success of a company in the market does not depend only on its manufacturing system.

Currently, companies worldwide are competing at the supply chain (SC) level, which has demonstrated to be a better strategy than competing as individual entities (Koh, Demirbag, Bayraktar, Tatoglu, & Zaim, 2007). According to Vaaland & Heide (2007),"SCM has increasingly become an important way to enhance competitive strength, and it is commonly argued that present day competition is between integrated supply chains rather than individual organizations" (p.20). Therefore, the successful implementation of lean philosophy requires commitment and discipline from every department in the company and assistance from the firm's supplier network (Harland, Caldwell, Powell, & Zheng, 2007).

One important component in the SC is logistics. According to Baudin (2005), logistics is comprised of all the operations needed to deliver goods or services, except making the goods or performing the services. As shown in Figure 1.1, logistics encompasses everything that happens outside the manufacturing walls; the flow of materials from the suppliers (known as inbound logistics), the flow of materials to the customers (known as outbound logistics), and the flow of the associated information. What happen in these supplier and customer networks impacts the efficiency and effectiveness of the company. One way to manage the

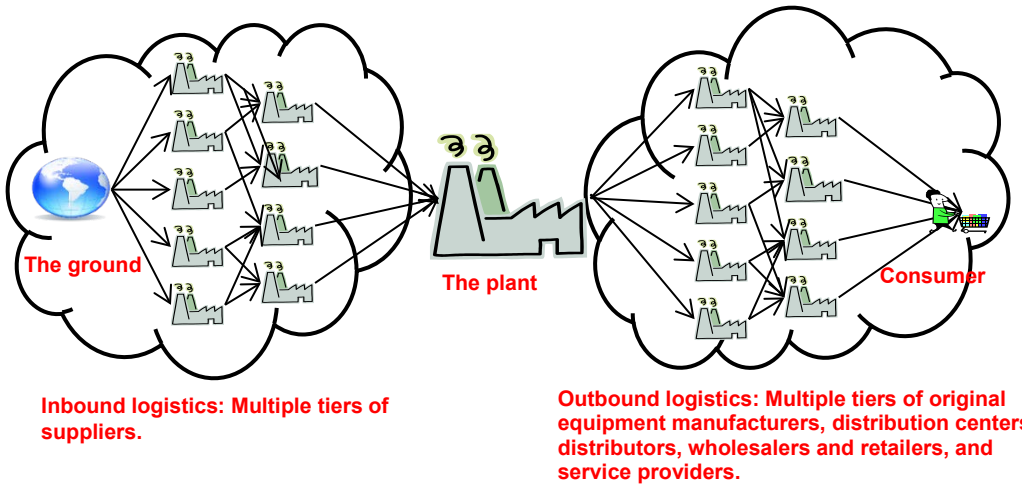


Figure 1.1 Inbound and outbound logistics (Baudin, 2005)

logistics operations of a company is through the application of lean logistics, which has been implemented by LEs like Toyota. According to Baudin (2005), lean logistics is defined as the logistics dimension of lean manufacturing. Its main objective is to deliver the right materials to the right locations, in the right quantities and in the right presentation; and do it all efficiently. This objective results in value added to the customers' perception of the product and might positively affect the price that they are willing to pay.

The benefits of the application of lean logistics are evident. However, the disadvantages are the costs, hazards and challenges associated to these practices. This is the reason why SMEs encounter more obstacles when implementing such practices and are less likely to harness their benefits (Vaaland & Heide, 2007). Additionally, the application of lean logistics might help SMEs in the manufacturing sector to solve the issues this industry faces on a

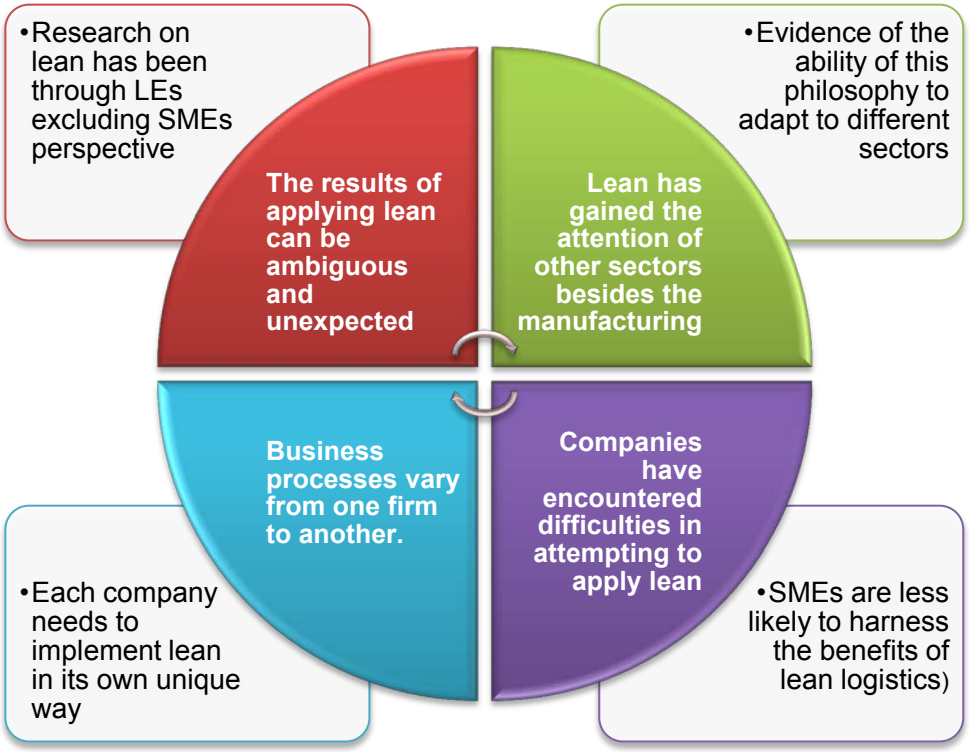


Figure 1.2 Problem Statement Summary

daily basis. Although these issues may vary from manufacturer to manufacturer and product to product; pressure on prices, short product lifecycles, mass customization, globalization, delivery times, strategic market planning, and SC security can be highlighted (Tompkins International, 2013).

Competition is based on capabilities, and the use of maturity models assumes that the process of achieving the goal comes in phases that represent the maturity of those capabilities (Lockamy & McCormack, 2004).

Few studies have been addressed lean logistics in SMEs. Karlsson & Åhlström (1997) addressed the question if the lean enterprise concept is suitable to small and medium-sized firms. Lee, Bennett, & Oakes (2000) examined the

extent a learning organization perspective is applicable to small and medium size manufacturers. Muda & Hendry (2002) demonstrated the applicability of new world class manufacturing in SMEs. Vaaland & Heide (2007) addressed the challenges that SMEs face and to what extent these companies are prepared to survive those challenges, and finally, Wilson & Roy (2009) discussed a method for enabling lean procurement for SMEs in New Zealand. This research proposes a lean logistics assessment tool for SMEs that will help them to identify their specific strengths, weaknesses, opportunities and threats in lean logistics practice.

1.5 Research Questions

The questions central to this research are:

RQ1: What are the objectives of lean logistics?

RQ2: What are the lean logistics critical factors?

RQ3: What are the lean logistics best practices within the critical factors for SMEs?

RQ4: What are the lean logistics capability levels?

RQ5: To what extent are the best practices matured in each level?

1.6 Assumptions

The following assumptions were inherent in this study:

1. There is a need to examine lean logistics from SMEs perspective.
2. SMEs can benefit from the implementation of lean logistics.
3. No significant difference can be found among SMEs in different countries; therefore, the critical factors can be generalized among all SMEs.
4. There is a need to establish the risks and critical factors that stop SMEs from implementing lean logistics.
5. A model or framework will help SMEs to identify and evaluate the barriers, and generate an implementation plan successfully.
6. There are experts at Purdue University who will provide input to this study.
7. The proposed model needs further validation through implementing the tool at logistics organizations.

1.7 Limitations

The following limitations are inherent to the pursuit of this study:

1. The literature on the application of lean logistics in SMEs is very limited.
2. This study is limited by the amount of cooperation of the experts on this topic available at Purdue, and their availability to address the model and evaluate its flaws.

1.8 Delimitations

The following delimitations are inherent to the pursuit of this study:

1. This study focuses only on the logistics system, not the overall supply chain.
2. The identification of the risks and critical factors is limited to those inherent to SMEs.

1.9 Definitions

Lean Logistics – is the logistics dimension of lean manufacturing.

Lean Manufacturing – a management philosophy that aims to meet or exceed customer expectations by eliminating sources of waste in the production flow (Bhasin & Burcher, 2006).

Logistics –part of the supply chain responsible for planning, implementing, and controlling the movement and storage of goods, services, and the information associated (Bowersox, 1997).

Maturity Model – this term refers to a framework that is used as a benchmark for comparison when looking at an organization's processes.

SMEs – this term refers to those enterprises with less than 250 employees, regardless of annual revenue.

Supply Chain Management – set of processes or activities required to integrate suppliers, manufacturers, and final consumers to ensure that the products are produced at the right quantities, to the right locations and at the right

time in order to satisfy service level requirements (Simschi-Levi, Kaminsky, & Simschi-Levi, 2003).

1.10 Chapter Summary

Lean manufacturing is a methodology that originated in the manufacturing environment but has gained interest among different industries. Its application has been extended to different business processes within the companies including lean logistics. However, further research is needed in lean logistics and its application in SMEs. These enterprises could benefit from a tool that helps them identify barriers and opportunities for the implementation of lean logistics, which is the goal of this study. This chapter provides an overview of a research proposal on lean logistics for SMEs, including significance, background, statement of purpose, problem statement, research questions, assumptions, limitations, delimitations and definitions.

CHAPTER 2. LITERATURE REVIEW

2.1 Lean Thinking

Lean thinking is more than a management technique; it is a way of thinking that generates a culture of continuous improvement in the organization (Womack & Jones, 2010). Practitioners and academics are not surprised that organizations are successfully embracing lean thinking. The goal of lean is to increase profits by increasing productivity and reducing costs. This goal is achieved by applying continuous improvement and eliminating waste by focusing on customers. According to Perrin (2006), lean thinking is based on a number of principles, which include:

1. Just in time: Production delivers what is needed when it is needed.
2. Jidoka: Stopping processes as soon defects or issues are identified.
3. Kaizen: This refers to continuous improvement to eliminate waste.
4. Genchi Genbutsu: Promotes assessing problems directly and empowers employees to solve them.
5. Challenge: As a result of continuous improvement, employees are constantly challenged to improve service levels and create more efficient budgets.

Although these principles were developed under the manufacturing environment, they have been adapted to many other business models including services; and in different functional areas including customer relations, information technology, human resources and sales among others (Sternberg, 2013). This demonstrates the adaptability of this philosophy and opens out an opportunity to explore the application of lean thinking in logistics operations.

2.2 Supply Chain Management

The conditions in which companies currently compete have changed. Instead of isolated entities, companies are competing as networks composed of different entities such as suppliers, manufacturers, and warehouses. Managing the flow of information, material, money, manpower and capital equipment among these entities provides the ability to efficiently integrate their components, which is the goal of SCM (Simschi-Levi et al., 2003). According to Ross (1997), “SCM is a comprehensive, dynamic, growth-oriented and competitive-winning management approach to thriving in a business environment driven by global change and uncertainty” (p.1). SCM encompasses many areas in these networks and the creation of strategies to integrate them around common goals. According to Croom, Romano, & Giannakis (2000) some of these areas are purchasing, logistics and transportation, marketing, organizational behavior, system engineering, and strategic management among others. Table 2.1 summarizes the principal components that are considered part of the SC.

Even though all of these areas are important and contribute to the successful performance of the SC, this research project concentrates only on the topics under the logistics category. When adopting SCM, managers need to incorporate practices that allow them to act or behave according to this philosophy. These practices include integrated behavior, information sharing, reward systems, cooperation, shared goals and focus on customer service, processes integration and finally partnerships to build or maintain long term relationships (Mentzer et al., 2001).

2.3 Logistics

According to Mentzer et al. (2001), SCM emerged from the logistics concept. This idea has continued to grow and gain importance within the SC philosophy due to the critical nature of today's enterprises. As one of the supply chain functions, logistics deals with the efficient flow and storage of goods. Ross (1997) explains that the role of logistics includes warehousing and transportation of goods throughout the whole supply chain, integrating all the suppliers' logistics operations. Logistics put more emphasis on more efficient movement and storage of goods to fulfill customer requirements. The areas within logistics include:

1. Transportation: This activity ensures the timely delivery of quality goods in a timeframe acceptable to the customer.

Table 2.1 Principal component bodies of SC literature (Croom et al., 2000)

Strategic Management	Relationship/partnership
Strategic networks	Relationship development
Control in the supply chain	Supplier development
Time-based strategy	Strategic supplier selection
Strategic sourcing	Vertical disintegration
Vertical disintegration	Partnership sourcing
Make or buy decisions	Supplier involvement
Core competencies focus	Supply/distribution base integration
Supply network design	Supplier Assessment (ISO)
Strategic alliances	Guest engineering concept
Strategic supplier segmentation	Design for manufacture
World class manufacturing	Mergers acquisitions, joint ventures
Strategic supplier selection	Strategic alliances
Global strategy	Contract view, trust, commitment
Capability development	Partnerships performances
Strategic purchasing	Relationship marketing
Logistics	**Best Practices**
Integration of material and information flow	Physically efficient vs. Market oriented supply chains
JIT, MRP, waste removal, VMI	JIT, MRP, MRP II
Physical distribution	Continuous improvement
Cross docking	Tiered supplier partnerships
Logistics postponement	Supplier associations
Capacity planning	Leverage learning network
Forecast information management	Quick response, time compression
Distribution channel management	Process mapping, waste removal
Planning and control of material flow	
Marketing	**Organizational behavior**
Relationship market	Communication
Internet supply chain	Human resources management
Customer service management	Employees' relationships
Efficient consumer response	Organizational structure
Efficient replenishment	Power in relationships
After sales service	Organizational culture
	Organizational learning
	Technology transfer
	Knowledge transfer

2. Operations: This activity encompasses the efficient execution of operations related to production, warehousing, distribution, and delivery in order to reduce costs, increase profits and keeping acceptable customer service levels.

3. Inventory: This activity aims to maintain customer service level while keeping lower inventory levels, therefore, reducing holdings costs.
4. Information: The use of information technology facilitates communication in the SC and allows faster response to customer needs by shrinking order cycle times and facilitating planning operations.
5. Special functions: This function deals with especial requirements such as sustainability, reverse logistics or marketing activities as well.

2.4 Challenges of SMEs

Even though there is not a broadly accepted definition of SMEs in the United States, SMEs in the manufacturing sector can be considered those with less than 250 employees regardless of annual revenue (Hammer et al., 2010). Logistics and supply chain management challenges are especially critical for this type of enterprises. Vaaland & Heide (2007) conducted a study in Norwegian of approximately 200 companies, in order to identify main differences in SCM practices between SMEs and LEs. The results suggest the existence of a big technology gap between SMEs and LEs. This provides an advantage for LEs and weakens the SMEs ability to build competitive strength. According to Vaaland & Heide (2007), it would be difficult for SMEs to survive in the current market if they continue underestimating the importance of using technology and e-commerce. Pingyu & Yu (2010) stated that the resource constraints of SMEs create difficulties to adopt all lean principles, which is an important technique to compete in global marketplace. The SMEs have to strive for world class

performance through implementation of lean manufacturing. However, a case study in two companies by Jensen & Jensen (2007) demonstrated that lean implementation can be successful in SMEs. These cases required an adaptive approach during the implementation phase according to the specific conditions of the company. Table 2.2 presents the strengths and weaknesses of SME to adopt lean manufacturing.

Table 2.2 Strengths & weaknesses of SME's (Antony, Kumar, & Madu, 2005)

SMEs strengths	SMEs weaknesses
Flexibility: changes can be introduced faster	Low degree of standardization and formalization
Culture of learning instead of controlling	Focus on operational matters instead of planning
Top management highly visible and lack of bureaucracy	Decisions are generally made for short-term profitability
Tend to have high employee loyalty	Budget and resources constraints
Decisions are execution and implemented quickly	No systems oriented
Flat organizational hierarchy, few layers of management and departmental interfaces	Lack of skills, time and resources; no specified training budget
More responsive to market needs and customers' demand	Formation of strategy process is intuitive rather than analytical

2.5 Lean logistics as a strategy

The way that logistics has traditionally been viewed is changing. Instead of one isolated no-value added activity, logistics is now recognized as a source of competitive advantage with great impact on a company's performance. Therefore,

logistics has become part of the lean journey, extended to the supplier network and customers. The challenge lies in engaging these areas to reduce waste and create flow. To apply lean in the SC, companies must develop problem solvers and create a culture of continuous improvement. This study resulted in the development of an assessment tool to rate best practices and to quantify the maturity of lean logistics operations in SMEs in the manufacturing sector; therefore, it was necessary to extend the understanding of the objectives, critical factors, best practices, and capability levels of SMEs in lean logistics.

2.5.1 Lean Logistics Objectives

According to Martichenko (2013), there are 8 key principles in Lean SC:

1. Waste elimination in any form, including system complexity, human effort, lead time, transportation, space, inventory, and packaging: Waste elimination contributes to the creation of harmony between different departments and provides an environment of cooperation.
2. Customer consumption information available to all members in the supply chain: Visibility of consumer information across the whole supply chain facilitates work planning based on pull information.
3. Lead time reduction: This reduction results in better customer service levels, reduced reliance on forecasts and better use of pull systems.
4. Leveled flow of material and information: This principle means having more predictable, consistent and uninterrupted flow of goods and information that reflects the actual demand.

5. Pull system implementation: The use of this inventory replenishment method contributes to reduce inventory.
6. Variation reduction and increased velocity: This translates to delivery of smaller shipments more frequently.
7. Collaboration: This requires a revised strategy where all the members in the supply chain work as partners instead of competitors, sharing consumer information.
8. Identification of total cost of fulfillment: The goal is to meet or exceed customer expectations at the least cost possible.

2.5.2 Lean logistics Critical Factors for SMEs

According to Boynton & Zmud (1984), critical success factors are “those few things that must go well to ensure success for a manager or an organization, and, therefore, they represent those managerial or enterprise areas that must be given special an continual attention to bring about high performance” (p.17).

Many important areas or factors need to be evaluated in lean applications and its adaptation of logistics. Ross, (1997) listed 5 function within logistics, including: 1) transportation, 2) operations, 3) inventory, 4) information, and 5) special functions.

Taj (2008) evaluated 65 companies in 9 areas in the manufacturing environment: 1) inventory, 2) team approach, 3) processes, 4) maintenance, 5) layout/handling, 6) suppliers, 7) setups, 8) quality, 9) scheduling, and 10) control. Although the intent of this study was not to focus on lean application in the

manufacturing environment, some of the factors have a great impact on the logistics operations as well.

Croom et al. (2000) summarized the principal components of logistics literature as: 1) integration of material and information flow, 2) JIT, MRP, waste removal, VMI, 3) physical distribution, 4) cross docking, 5) logistics postponement, 6) capacity planning, 7) forecast information management, 8) distribution channel management, and 9) planning and control of material flow.

Goldsby & Martichenko (2005) classified logistics wastes through seven factors: 1) inventory, 2) transportation, 3) space and facilities, 4) time, 5) packaging, 6) administration, and 7) knowledge. Finally, Baudin (2005) organized his book throughout the following topics: 1) transportation, 2) warehousing, 3) material flow, 4) packaging, 5) information.

2.5.3 Lean logistics best practices and capability levels for SMEs

Many assessment tools have been developed to evaluate SCM practices. The capability levels of these studies would be a starting point to develop the capability levels for lean logistics. The CSC Framework Model proposed by Poirier (2004) proposes 5 different levels, with level 1 being the most precarious and level 5 the strongest. The Supply Chain Operations Reference Model (SCOR) proposed by Lockamy & McCormack (2004) describes 5 levels as well (ad hoc, defined, linked, integrated and extended). Finally, the Supply Chain Process Maturity Model (SCPM3) proposed by de Oliveira, Ladeira, & McCormack (2011) includes foundation, structure, vision, integration and dynamic levels.

2.6 Maturity Models and Assessment Tools

Lockamy & McCormack (2004) stated that continuous process improvement acts as the energy that promotes process maturity to new levels. Assessment is the most valuable tool to determine the current state of any process and requires benchmarks against which to be assessed. In order to implement lean logistics or improve logistics operations, it is vital to determine the current state of operations and business processes at the company.

Lockamy & McCormack (2004) also stated that “as processes mature, they move from an internally-focused perspective to an externally focused system perspective. A maturity level represents a threshold that, when reached, will institutionalize a total systems view necessary to achieve a set of process goals” (p. 273). According to De Bruin, Freeze, Kaulkarni, & Rosemann (2005), a design principle in maturity models is to establish the maturity levels as an accumulation of stages, where higher stages are built on lower stages.

The National Quality Council (2009) defines assessment tools as instruments and/or procedures utilized to collect and interpret evidence of competence. Instruments refer to the questions used to assess, and procedures refer to the instructions or guidelines given to the assessor about how to conduct the assessment. This council also affirms that the quality of any assessment tool is measured by the ability of another assessor to repeat the assessment without any further explanation by the developer. Table 2.3 summarizes the ideal characteristics of an assessment tool adapted from the National Quality Council (2009).

Table 2.3 Ideal characteristics of an assessment tool. Adapted from National Quality Council (2009)

Component	Description
The context	The purpose and target population is defined.
Competency Mapping	The components that the tool should cover are described.
The information to be provided to the candidate	Outlines the task(s) to be completed by participant/respondent.
The evidence to be collected from the respondent	Provides information on the type of information to be provided by the respondent.

The National Quality Council (2009) also proposes quality checks to be completed as part of the quality assurance of the assessment tool. One of these quality checks, that was used in this research, is revision by subject matter experts. The experts should critique the tool for:

- ✓ Clarity
- ✓ Content accuracy
- ✓ Relevance
- ✓ Content validity
- ✓ Avoidance of bias
- ✓ Appropriateness of language for the target population
- ✓ Clarity of instructions for completion
- ✓ Clarity of instructions for administration by assessors

2.7 SWOT Analysis

SWOT or Strengths, Weaknesses, Opportunities and Threat analysis is a tool that has been widely used by consultants, marketers and even students and practitioners. The merit of this tool lies in its ability to assess and support complex decision situations (Helms & Nixon, 2010). The main goal of a SWOT analysis is to support the creation of strategic plans for an organization and support the design of a suitable pathway or action plan. According to Coman & Ronen (2009), SWOT remains a major strategic planning tool and provides the opportunity to identify strengths and weaknesses and convert them into core competences and core problems. SWOT analysis is very helpful to enumerate and classify issues but it does not generate actual solutions or strategies to implement. SWOT analysis is the first step to tackle an improvement initiative by clarifying a business landscape, but it is required to add many other techniques in order to achieve actual solutions.

2.8 GAP Analysis

Addagada (2012) stated that GAP analysis is a tool used to in companies to determine current a desired states on a specific situation. The situation can be a strategic switch, market conditions analysis and process improvement among others. Addagada (2012) affirmed that GAP analysis allows the analysis of internal capabilities and future capabilities by performing as-is and to-be investigations.

CHAPTER 3. METHODOLOGY

As discussed in the preceding chapters, there is a need to assess lean logistics best practices in SMEs. This study created an assessment to determine the maturity of lean logistics operations in SMEs. The methodology used to develop the tool is illustrated in Figure 3.1 and described below:

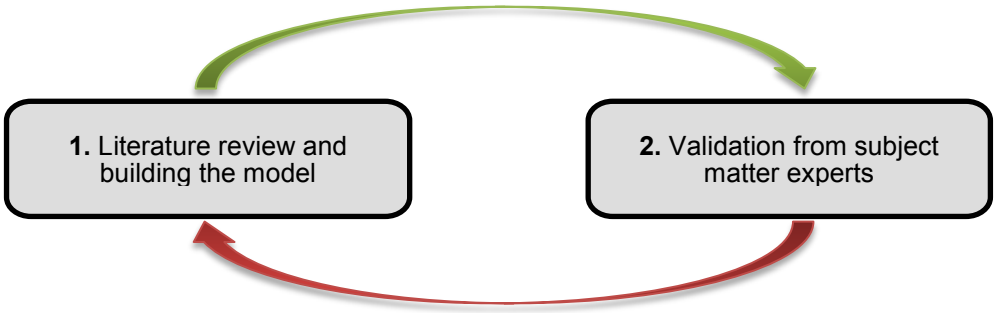


Figure 3.1. Methodology

3.1 Step 1: Literature review and creation of the assessment tool

The different activities that are part of the step 1 are described below:

3.1.1 Picking the model

The goal of this activity was to determine which template, if any, would be more suitable to use in the creation of the tool.

3.1.2 Identifying the key elements needed to build the model

After the tool template was chosen, the next activity was to identify the key elements or components of the tool that needed to be addressed. Each of these key elements became one of the research questions and they refer to the lean logistics objectives, critical factors, best practices and capability levels.

3.1.3 Reviewing the literature to define the key elements:

The literature review was the backbone of the tool as it represents the activity that allowed the definition of each of the key elements or components of the tool. This activity consisted of an in-depth review of the current lean logistics concepts to define the key elements that were identified in the previous activity. Each of these key elements; that correspond to one of the research questions, were answered in this activity based on comparative analysis of the different authors.

3.1.4 Building the model

Once the research questions were answered, the next activity on this step was to build the tool. This tool integrates the critical factors, best practices and capability levels into one template that determines to what extent the best practices are matured in each maturity level. The tool design considers all the elements of an ideal assessment tool; for instance; context, competency mapping, decision making rules, range and conditions, and recording and reporting requirements.

3.1.5 Designing the results

After the assessment tool design was completed, the next activity was to design how to read the results. The best practices were classified into a SWOT analysis, providing the respondent with an overview of the current strengths that need no attention, weaknesses that require immediate attention, opportunities for improvement as well as threats that need close monitoring.

3.2 Step 2: Validation from subject matter experts

After a first draft of the assessment tool was completed, the next step was to send it to subject matter experts to evaluate the quality of the tool in different aspects. The following activities were part of this step:

3.2.1 Identifying the experts

The experts were chosen based on geographical location, Indiana, and they all have a background in lean thinking and logistics. A first email was sent out explaining the scope of the research and the type of collaboration that was required. The next activity took place only for those experts who agreed to participate.

3.2.2 Sending the tool through email

The first draft of the assessment tool was sent to 5 subject matter experts who agreed to participate in the study. The goal was to collect feedback related to factors, best practices and capability levels. The experts judged the tool based

on the criteria proposed by the National Quality Council (2009) that was described in the literature review.

3.2.3 Reviewing and incorporating feedback

After 5 weeks of sending the assessment tool for review, all the feedback was collected, analyzed and incorporated into the tool.

CHAPTER 4. RESULTS

This chapter describes the detailed explanation of how the methodology was applied and the results obtained:

4.1 Step 1: In depth literature review and assessment tool creation

The literature review was critical to the creation of the model and is considered the backbone of the model. Every activity that took place on step 1 is described below:

4.1.1 Picking the model

Initially, the approach took by the researcher was to develop the tool from scratch. The process started and a draft of the initial assessment tool was developed and it is shown in Table 4.1. Many issues were identified with this model and it was discarded. For instance, this model required the creation of numeric categories of the final score that define the maturity of all the lean practices combined. It also required the creation of a narrative describing the logic and characteristics of each these categories. However, this would not be very accurate because one company could be very strong in one critical factor but very weak in others and vice versa. Therefore, it was very difficult to make

generalizations on the results by category that would apply to each company that would fill out the assessment tool.

Table 4.1 Initial design of the assessment tool (discarded)

Factors/ Best practices	High	Medium	Low	N/A	Total
CRITICAL FACTOR 1					0
Question a. (Best Practice)					
Question b. (Best Practice)					
Question c. (Best Practice)					
CRITICAL FACTOR 2					0
Question a. (Best Practice)					
Question b. (Best Practice)					
Question c. (Best Practice)					

The next approach took by the researcher was to look for templates that were more suitable to the characteristics of the lean logistics topic and this research. After reviewing the literature, the best alternative was to use the template provided in the LAI Enterprise Self-Assessment tool (MIT, 2012). This assessment tool is the result of an effort led by the MIT Lean Advancement Initiative (LAI) and the purpose is to support companies in the lean transformation journey by assessing the lean practices pertinent to the transformation process, life cycle processes and infrastructure support. Table 4.2 illustrates the format of the expected tool.

Table 4.2 Format of the expected assessment tool, based on LAI Enterprise Self-Assessment tool (MIT, 2012)

Enterprise Practices		Capability Levels				
		Level 1	Level 2	Level 3	Level 4	Level 5
1	Best Practice 1					
	Current					
	Desired					
	Lean Rationale					
	Evidence					
	Opportunities					
2	Best Practice 2					
	Current					
	Desired					
	Lean Rationale					
	Evidence					
	Opportunities					

4.1.2 Identifying the key elements needed to build the model

Adopting the LAI Enterprise Self-Assessment tool (MIT, 2012) required the understanding of each of the components that was part of this template, and the translation of these components into the lean logistics tool that was being developed in this research. As a result, the following key elements were identified and became the research questions needed to be addressed in this research.

- ✓ Objectives
- ✓ Critical Factors
- ✓ Best Practices
- ✓ Capability levels
- ✓ Maturity for best practice at each level

4.1.3 Reviewing the literature to define the key elements

The key elements were addressed through an in-depth literature review. The literature review is the backbone of the tool as it represents the activity that allowed the definition of each of the key elements or components of the tool. This activity consisted of an in-depth review of the current lean logistics concepts to define the key elements that were identified in the previous activity. Each of these key elements; that correspond to one of the research questions, were answered in this activity based on comparative analysis of the different authors.

4.1.3.1 RQ1: Definition of Lean Logistics Objectives

After a thorough literature review, the 8 objectives to which this lean logistics assessment tool were proposed by Martichenko & Grabe (2010). These principles represent the core of lean logistics:

1. Waste elimination
2. Customer consumption visibility
3. Lead time reduction
4. Leveled flow of material and information
5. Pull system implementation
6. Increased velocity and reduced variation, which translates to delivery of smaller shipments more frequently
7. Collaboration
8. Total cost of fulfillment

4.1.3.2 RQ2: Definition of the critical factors

Five references (3 books and 2 papers) were found which contained definitions of the critical factors in logistics. Comparative tables were created to support the definition of the critical factors that were used in the creation of the lean logistics model. Table 4.3 lists all the factors that were identified. It was hard to determine which factors to choose from this table because there was nothing to differentiate or highlight one factor from the others. For that reason, the researcher proceeded to color code the factors, as illustrated in Table 4.4.

Table 4.3 Critical factors by author

Author/ Critical Factor	**Ross (1997)**	**Croom et al. (2000)**	**Goldsby & Martichenko (2005)**	**Baudin (2005)**	**Martichenko & Grabe (2010)**
1	Transportation	Integration of material and information flow	Inventory	Transportation	System Complexity
2	Operations	JIT, MRP, waste removal & VMI	Transportation	Warehousing	Lead Time
3	Inventory	Physical distribution	Space and facilities	Material flow	Transport
4	Information	Cross docking	Time	Packaging	Space
5	Special functions	Logistics postponement	Packaging	Information systems	Inventory
6		Capacity planning	Administration	Scheduling & forecasting	Human Effort
7		Forecast information management	Knowledge	Relationship & supply network	Packaging
8		Distribution channel management			
9		Planning and control of material flow			

Table 4.4 presents the critical factors and the color assigned to each one of them. For instance, green was assigned to transportation and any other critical factor that by definition refers to transportation. That is the case of Croom et al. (2000) who uses the term "physical distribution" instead of transportation but this factor is still color coded green. The same case occurs with Goldsby & Martichenko (2005) who refer to warehousing as "space and facilities". Pink was assigned to this category.

Table 4.4 Color Coded Critical Factors

Author/ Critical Factor	Ross (1997)	Croom et al. (2000)	Goldsby & Martichenko (2005)	Baudin (2005)	Martichenko & Grabe (2010)
1	Transportation	Integration of material and information flow	Inventory	Transportation	System Complexity
2	Operations	JIT, MRP, waste removal & VMI	Transportation	Warehousing	Lead Time
3	Inventory	Physical distribution	Space and facilities	Material flow	Transport
4	Information	Cross docking	Time	Packaging	Space
5	Special functions	Logistics postponement	Packaging	Information systems	Inventory
6		Capacity planning	Administration	Scheduling & forecasting	Human Effort
7		Forecast information management	Knowledge	Relationship & supply network	Packaging
8		Distribution channel management			
9		Planning and control of material flow			

The color coding made it easier to determine commonalities among authors. Finally, in Table 4.5 the factors were sorted by color in order to identify which

factors were common among different authors. As a result, 8 factors were found in at least 2 of the five authors, and 4 were unique to one specific author. The unique factors were independently analyzed in order to determine if new categories could be developed which have commonalities.

Table 4.5 Sorted Critical Factors

Author/ Critical Factor	Ross (1997)	Croom et al. (2000)	Goldsby & Martichenko (2005)	Baudin (2005)	Martichenko & Grabe (2010)
1	Inventory	JIT, MRP,VMI waste removal	Inventory		Lead Time
		Planning and control of material flow	Time		Inventory
2	Transportation	Physical distribution	Transportation	Transportation	Transport
				Material flow	
3	Operations		Administration		
4	Information	Integration of material and information flow	Knowledge	Information systems	
5	Special functions	Cross docking	Space and facilities	Warehousing	Space
6		Forecast information management		Scheduling & forecasting	System Complexity
		Capacity planning			
7		Logistics postponement	Packaging	Packaging	Packaging
8		Distribution channel management		Relationship & supply network	Human effort

As a result of this process, the following 8 factors we chosen as the critical factors of the lean logistics self-assessment tool:

I. Inventory

II. Transportation/ Material/ Physical distribution

III. Operation/ Administration

IV. Information/ Knowledge

V. Warehouse

VI. Forecasting and Scheduling

VII. Packaging

VIII. Supplier Relationship

Table 4.6 provides a brief definition of each of the 8 factors selected, according to each of the authors. These definitions were useful to keep focus in the next step that consisted on the selection of the best practices associated to the critical factors already chosen.

Table 4.6 Critical Factors Definition

Critical Factor	Ross (1997)	Croom et al. (2000)	Goldsby & Martichenko (2005)	Baudin (2005)	Martichenko & Grabe (2010)
Inventory	Inventory management methods that constantly search for ways to reduce inventory enable companies to better leverage financial resource that accentuate customer service needs	No definitions provided in this paper	The promise to serve a customer cannot be extended assuredly unless the product is on hand or available in as required, this is inventory.	It's considered one of the seven types of waste in the lean philosophy. But not all inventories are waste, just excess inventory. Inventory is as necessary to production as blood is to the human body.	Time it takes to get from one step to another

Critical Factor	Ross (1997)	Croom et al. (2000)	Goldsby & Martichenko (2005)	Baudin (2005)	Martichenko & Grabe (2010)
Transportation/ Material/ Physical distribution	This activity consists on ensuring the products delivery on time and with the expected quality.	No definitions provided in this paper	Transportation is a required activity in logistics. It allows to make products in one place and to consume them in another, closing the distance of geographic separation, so critical in global operations.	Transportation covers the movements of materials from suppliers to customers.	Movement of goods from one facility to another
Operation/ Administration	The ability to effectively execute internal and channel wide operations, such as production, warehousing, distribution, and delivery that enable companies to reduce costs, increase profits, and engineer flexible organizations	No definitions provided in this paper	Administration is a resource viewed by many people in business as a nonvalue-adding yet necessary. However, administration is necessary to run, even if it means a departure from the most efficient organization and the optimal flow of work.	No definition provided in this paper	No definition provided in this paper
Information/ Knowledge	Information management increases copetitiveness by shrinking order cycle times, reducing stocked and in-transit inventories and facilitating planning and operations activities	No definitions provided in this paper	Knowledge cannot be seen, touched, or easily quantified, but is very much a resource. Knowing what customers will buy, knowing how to build those products, knowing how to make customers aware of the offering.	Refers to the information structure that is built on top of the logistics process and that supports the company	No definition provided in this paper

Critical Factor	Ross (1997)	Croom et al. (2000)	Goldsby & Martichenko (2005)	Baudin (2005)	Martichenko & Grabe (2010)
Warehouse	No definition provided in this paper	No definitions provided in this paper	The need of buying materials and make products in advance requires facilities available to ensure the integrity and value of materials and goods.	Warehouses respond to the need of storing and retrieving materials.	Places used to store inventory
Forecasting and Scheduling	No definition provided in this paper	No definitions provided in this paper	No definition provided in this paper	Scheduling based on kanbans.	Scheduling systems and decisions that match current schedule with actual needs
Packaging	No definition provided in this paper	No definitions provided in this paper	Packaging refers to all forms of containerization at the item and bundle levels. It includes outer packaging for an item as well as the dunnage that secures an item within a package.	The importance of packaging lies in its ability to protect the product and the environment, convenient picking and communication information among others	Forms of containerization that can result in damages and excessive inventory
Supplier Relationship	No definition provided in this paper	No definitions provided in this paper	No definition provided in this paper	Proposes to move supplier-customer relationships from an adversarial model to a collaborative approach	No definition provided in this paper

The lean logistics objectives and critical factors that were defined in the previous sections determine the roadmap that companies need to keep in mind when starting the lean logistics journey. Figure 4.1 integrates and summarizes the lean logistics objectives and critical factors that have been identified and that would be subject of the model.

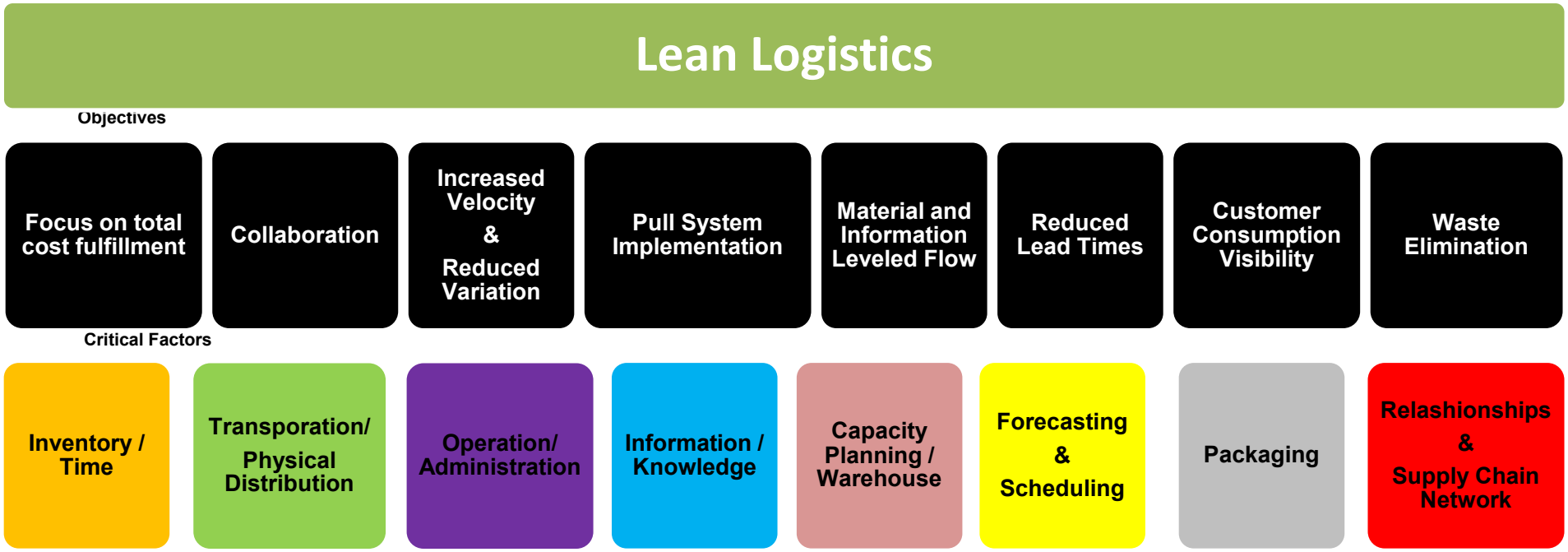


Figure 4.1 Lean Logistics Objectives and Critical Factors

4.1.3.3 RQ3: Definition of lean logistics best practices

The best practices list was selected based on literature. These best practices were found to be general, meaning that they apply to any kind of enterprise without taking into account the size. However, in order to build the model, only the best practices that better fit SMEs were selected. This selection was based on the researcher discernment and is listed below:

I. Inventory/ Time

- ✓ Keep the minimum inventory level minimum that guarantees production and final customer needs (Baudin, 2005).
- ✓ Respond to customer orders by delivering small quantities more frequently will result in higher inventory turns (Goldsby & Martichenko, 2005).
- ✓ High inventory turns can be also be counterproductive since it may result in increased shipping costs. Therefore, the company needs to accurately determine the cost of carrying inventory (Goldsby & Martichenko, 2005).
- ✓ Coordinate production planning and inbound logistics in order to smooth consumption and reduce the impact of lead times (Baudin, 2005).
- ✓ Customer's inventory and purchasing system communicate with the supplier's automatic order entry system (Goldsby & Martichenko, 2005).
- ✓ The logistics system must be designed to the respond to the specific needs of the company, considering the required quantities and frequency of use (Baudin, 2005).

- ✓ Training is provided to employees with regard to the inventory policies and practices in the company (Baudin, 2005).
- ✓ The company is provided with access to the customer's inventory database and is allowed to send shipments once the reorder point is reached (Baudin, 2005).
- ✓ Manufacturing Execution Systems (MES) are used to anticipate shortages and trigger warnings to execute contingency plans in case of shortages (Baudin, 2005).
- ✓ Logistics managers keep inventory on vigilance, detecting anomalies early and responding quickly (Baudin, 2005).
- ✓ Reliance on safety stock is minimized and safety stock levels are reduced to its minimum. The inventory manager focuses on process issues that may arise from this reduction (Goldsby & Martichenko, 2005).

II. Transportation/ Material/ Physical distribution:

- ✓ The logistic system is designed to transfer small quantities of a large number of items (Baudin, 2005).
- ✓ The company has a selected number of carriers for all its transportation needs. This results in volume discounts and higher priority service due to the higher volumes (Goldsby & Martichenko, 2005).
- ✓ Shipping personal are provided with routing guides for all shipping locations that define the order in which the carriers should be contacted in search of service (Goldsby & Martichenko, 2005).

- ✓ The company fosters partnerships with carriers that result in mutual benefits such as priority service and rate negotiations. The goal is lower system costs, not only transportation costs (Goldsby & Martichenko, 2005).
- ✓ When possible, shipments less-than-truckload (LTL) are planned in a way orders can be combined and transported by only one truckload carrier (Goldsby & Martichenko, 2005).
- ✓ In transportation, all the efforts are focus toward minimizing the average delivery time and the variation around that average (Goldsby & Martichenko, 2005).

III. Operation/ Administration:

- ✓ 3rd party logistics (3PLs) are not utilized to offer services that require product knowledge (Baudin, 2005).
- ✓ There are customer service policies established and are used to as a reference to make decisions that will affect customers' expectations (Goldsby & Martichenko, 2005).
- ✓ The company has established guidelines for dealing with problematic situations that will result in cost savings (Goldsby & Martichenko, 2005).
- ✓ The company's philosophy is spread out to every employee towards eliminating waste in any form, even if it is beyond their responsibilities (Goldsby & Martichenko, 2005).
- ✓ The company uses technological solutions that ease warehouse administration (Goldsby & Martichenko, 2005).

- ✓ The lean logistics philosophy is a corporate initiative that permeates all levels in the organization (Goldsby & Martichenko, 2005).

IV. Information/ Knowledge:

- ✓ Parts, either raw material or finished products, only moved to the next stop when a pull signal is activated, announcing that the destination is ready for them (Baudin, 2005).
- ✓ Employees have easy access to managers and systems (Baudin, 2005).
- ✓ The use of information systems supports market visibility by allowing direct communication between customers and suppliers (Baudin, 2005).
- ✓ The exchange of information through ERP systems is used to enhance communications between customers and suppliers, where the forecast of finished goods might be considered orders, with a compensation agreement in case of consistent optimistic forecasts (Baudin, 2005).
- ✓ The company promotes formal and informal means of knowledge (Goldsby & Martichenko, 2005).
- ✓ There are mechanisms in place that help to ensure a flow of information and knowledge among all the collaborators in the company, avoiding the generation of “islands of knowledge” (Goldsby & Martichenko, 2005).

V. Warehouse:

- ✓ The warehouses are designed according to the specific company needs (Baudin, 2005).

- ✓ The company uses a combination of dedicated and allocates slots. Dedicated are used for high volume items, whereas allocated are used for other items (Baudin, 2005).
- ✓ Within the warehouse, spaces with easy access are assigned to items used frequently, regardless of the quantity (Baudin, 2005).
- ✓ Items that are infrequently used have dynamic/random allocation (Baudin, 2005).
- ✓ Manager is comfortable or has been exposed to different warehouse management approaches (Baudin, 2005).
- ✓ The warehouse Management System (WMS) in place supports different storage methods, and allows them to coexist in the same warehouse (Baudin, 2005).
- ✓ Column grids that support the ceiling in the warehouse are properly labeled (Baudin, 2005).
- ✓ Docks are numbered and the number is placed in such a way that remain visible when the docks are open (Baudin, 2005).
- ✓ The zone identification signs are three-sided, so they are visible from difference perspectives (Baudin, 2005).
- ✓ Every aisles, columns and levels are properly labeled on each slot in a pallet rack (Baudin, 2005).
- ✓ Separators between slots are used as needed (Baudin, 2005).
- ✓ The rack aisles are located so that they do not block the view (Baudin, 2005).

- ✓ Items provided by problematic suppliers are organized in such a way that they are easy to monitor (Baudin, 2005).
- ✓ The system allows retrieval of up-to-date maps that have been updated by scanning barcodes or RFID tags (Baudin, 2005).
- ✓ The maximum occupancy in which the warehouse operated is around 85% (Baudin, 2005).
- ✓ Materials are tracked in and out of the warehouse through auto-ID technology (Baudin, 2005).
- ✓ Container design must facilitate cycle counting and inventory visibility (Baudin, 2005).
- ✓ Employees must be treated with respect by the security personnel as a result of good communication management practices and warehouse visibility (Baudin, 2005).
- ✓ Materials are never taken out the warehouse without recording item number and quantity (Baudin, 2005).
- ✓ Cycle counting must be a practice applied for a few items in a daily basis or minimally, on a rotating basis (Baudin, 2005).

VI. Forecasting and Scheduling:

- ✓ Products are only moved to the next stop when a pull signal (e.i purchase order) is activated, announcing that the destination is ready for them (Goldsby & Martichenko, 2005).

- ✓ Align the shipping and receiving schedules to match customer consumption (on the outbound side) with the pull of manufacturing material (on the inbound side) (Martichenko & Grabe, 2010).
- ✓ For inbound logistics, different replenishment processes are assigned to different products to fit specific needs (Martichenko & Grabe, 2010).

VII. Packaging

- ✓ The company prefers the use of returnable containers for packaging parts in transit instead of disposable containers (Baudin, 2005).
- ✓ The company regularly revise the benefits obtained from the packaging that is currently in use, in aspects such as how difficult it is to pack, lift, carry, lower, unpack, and dispose of the container (Goldsby & Martichenko, 2005).
- ✓ Polices are in place to promote the use of returnable containers or recyclable packaging (Goldsby & Martichenko, 2005).
- ✓ Packaging design is used as a source of visual control and activity in the supply chain (Goldsby & Martichenko, 2005).

VIII. Relationship & supply network

- ✓ Supplier metrics are used to classify suppliers according to their performance in 3 categories: ethical, needing help to get certification, and candidates for replacement (Baudin, 2005).
- ✓ The supplier metrics are based on delivery and quality, and not only on prices (Baudin, 2005).

- ✓ The company negotiates with a small number of direct suppliers. Each one of these direct suppliers manages a group of small suppliers (Baudin, 2005).
- ✓ The company does not source the same item from different suppliers. Instead, the company uses a single sourcing strategy, making the supplier responsible for second-sourcing agreements (Baudin, 2005).
- ✓ Product design is completed by multidisciplinary engineering teams of suppliers and customers. The goal is to achieve target costing, value engineering, and Design for Manufacturing and Assembly (DFMA) (Baudin, 2005).
- ✓ Suppliers are upfront with any problem or issue, and the company is willing to collaborate in finding effective solutions (Baudin, 2005).

4.1.3.4 RQ4: Definition of lean logistics capability levels

Many assessment tools have been developed to evaluate general SCM practices. For this assessment tool, the researcher was debating between using a 3 or 5 capability levels model. After completing a comparative analysis between some SCM models, the decision was made to use a 5 levels model for the lean logistics assessment tool. Three models that were compared are: Poirier (2004), Lockamy & McCormack (2004), and de Oliveira, Ladeira, & McCormack (2011) and they all had 5 levels. Table 4.7 summarizes the characteristics of each of the levels proposed by the different authors. Finally, common characteristics were identified between publications.

Table 4.7 Previous maturity levels used in other models

Level	CSC (Poirier, 2004)	SCOR (Lockamy & McCormack, 2004)	SCPM3 (de Oliveira et al., 2011)
1	The main inefficiencies faced by many companies concern the results of low inter-organization integration process, the barriers in businesses works, and the no-happening or no-expressive sharing between information systems and agents in the expanded value chain	**Ad Hoc** - is characterized by poorly defined and bad structured practices. Process measurements are not applied and work and organizational structures are not based on the horizontal process of the supply chain. Performance is unpredictable and costs are high. Cross-functional cooperation and client satisfaction levels are low.	**Foundation** – is characterized by building a basic structure, aiming to create a foundation for the processes to avoid ad hoc procedures and unorganized reactions, looking to stabilize and document processes. At this level, the critical business partners are identified and order management best practices are implemented considering restrictions of capacity and customer alignment.
2	Attention is given to logistics gains, focusing more on the use of actives and the effectiveness of its physical distribution. Demand management becomes a critical factor, and the preciseness of predictions can be the main driving force for more acuity on the company's operations in the planning, programming and production control areas. Supply chain orientation gains more importance with a more strategic management of the organization's immediate supplier and client bases.	**Defined** - SCM's basic processes are defined and documented. There is neither work nor organizational structure alteration. However, performance is more predictable. In order to overcome company problems, considerable effort is required, and costs remain high. Client satisfaction levels improve but still remain low if compared to levels reached by competitors.	**Structure** – processes start to be structured in order to be further integrated. Control items are implemented in demand management processes, production planning and scheduling and for the distribution network management. Downstream, distribution network management practices are structured and the processes are defined. Demand starts to be evaluated in more detail. In other the direction, the processes of production planning and scheduling are structured taking the demand management and forecast as inputs.
3	The company develops or redesigns its inter-organizational processes and starts to create a business network with few and carefully selected allies. During this stage,	**Linked** - the application of SCM principles occurs (Supply Chain Management). The organizational structures become more horizontally prepared through the	**Vision** – process owners are established and become responsible for its management and performance results. Procurement processes are evaluated by a team

Level	CSC (Poirier, 2004)	SCOR (Lockamy & McCormack, 2004)	SCPM3 (de Oliveira et al., 2011)
	important suppliers are invited to participate in planning, operations, and sales sessions (S&OP – Sales and Operation Planning), bringing supply and demand closer to each other. Global relationships are established with logistical service suppliers, qualified in relation to transport functions, logistics and storage, and clients are encouraged to give feedback regarding current and desired products. Business allies, at this level, work together, using various tools and collaborative techniques to reduce, through mutual initiatives and shared results, cycle times, especially time-to-market, using their actives more efficiently	creation of authorities that overlooks functional units. Cooperation among intra-organizational functions, supply managers and clients transform into teams that share measures common with SCM, and into objectives with a horizontal scope in the supply chain. Efforts for continuous improvement are made aiming to stop problems early and thus achieve better performance improvement. Cost efficiency grows and clients start to get involved directly in the improvement efforts of intra-organizational processes.	that looks strategically to the acquisitions in order to align the interests of the marketing and operations department. At this level, organization can be assumed to start to develop a strategic behavior considering a broader perspective of the supply chain.
4	This level is characterized by collaborative initiatives. Companies start using methodologies such as Activity Based Costing (ABC) and the Balanced Score Card to transform the supply chain into a value network of partners, who work towards the same strategic goals. Information is shared electronically, and inter-company teams are formed to find solutions for specific client problems. E-commerce technologies are considered crucial for this level, guaranteeing real-time sharing of all relevant information at each point of the value chain. Development and use of models and methodologies	**Integrated** - the company, its suppliers, and clients strategically cooperate in the processes' levels. Organizational structures and activities are based on the SCM principles and traditional tasks, related to the expanded value chain processes, start to disappear. Performance measurements for the supply chain are used, with the advent of advanced practices, based on collaboration. The process improvement objectives are geared towards teams and well reached. Costs are drastically reduced, and client satisfaction, as well as team spirit, becomes a competitive advantage	**Integration** – companies seek to build a collaborative environment with their supply chain business partners. The organizational processes integrate with the processes of suppliers and customers in a collaborative platform. The forecasts are developed in detail, considering the demands of each customer individually. The relationship with upstream partners becomes more solid and integrated. The company, based on a set of concrete metrics and health data about the process flow, starts to use analytics and become more strategically driven

Level	CSC (Poirier, 2004)	SCOR (Lockamy & McCormack, 2004)	SCPM3 (de Oliveira et al., 2011)
	for implementation in design, planning and collaborative replenishment are crucial at this stage.		with its supply chain partners.
5	It is a developmental stage characterized by a complete join between agents throughout the whole supply chain. According to Pourier and Quinn (2003; 2004), only a few organizations in a few sectors reach this stage. It is a stage of complete collaboration throughout the network and of strategic use of technology information to achieve position and status in the market. At this stage, companies usually reach extraordinary order prediction levels as well as a reduction in the cycle time throughout electronic networks.	**Extended** - competition is based in multi-organizational supply chains. Multi-organizational SCM teams appear with expanded processes, recognized authority and objectives throughout the supply chain. Trust and auto-dependence build the support base of the extended supply chain. Process performance and trust in the extended system are measured. The supply chain is characterized by a client-focused horizontal culture. Investments in the system's improvement are shared, as well as the investment's return.	**Dynamics** – is characterized by a strategic integration of the chain, when processes support collaborative practices between partners and generate a baseline enabling the chain to be responsive to market changes. The chain starts, therefore, to behave dynamically, continually improving its processes considering its key performance indicators and reacting synchronized and fast to the changes in the competitive environment.

4.1.3.5 RQ5: Maturity for best practice at each level?

To answer this question, it was necessary to take each of the best practices and try to divide them into 5 levels, describing the main characteristics on each of the levels. This description was completed by each of the 48 best practices and was developed under the principle that maturity levels are established as an accumulation of stages, where higher stages are built on lower stages. Table 4.8 illustrates the definition of each of the 5 maturity levels for best practice 1 in the critical factor transportation.

Table 4.8 Sample of the 5 maturity levels for Best Practice 1 in the Critical Factor Transportation

	Enterprise Practices			Capability Lev		
		Level 1	Level 2	Level 3	Level 4	Level 5
1	The company has a selected number of carriers for all of its transportation needs.	Carriers are changed too often and the decision is based on price only	Carriers are changed with some regularity, and decisions are based on prices and service level	Carriers are not often changed, however, attempts to create partnerships have been done without success	The company usually do business with the same carriers, and negotiate mutual benefits in the short term	The company works closely with selected carriers; finding value in partnering that results in opportunities for mutual benefit

4.1.4 Building the model

After all the information was identified and the research question responded, the next activity was to combine everything into the model. This step required putting together one template for each of the critical factors, including the best practices defining each one. The combination of the research questions 1, 2, 3, 4 and 5 provided all the elements required to create the assessment tool. Table 4.9 illustrates the capability levels of the best practices number 1 and 2 in the critical factor transportation. In similar way, all the capability levels are described for all the best practices in the tool.

4.1.5 Interpreting the assessment results

Another important step in developing the tool was defining how the results were presented once the assessment has been filled out. Following the structure presented in the LAI enterprise self-assessment tool (MIT, 2012), the respondent should score each enterprise practice in two dimensions. First, provide a score for the current stage in which the company performs in each specific practice. Second, provide a score for the desired stage based on what the company

Table 4.9 Excerpt of maturity levels for best practices in Transportation

Critical Factor II: Transportation, Material and Physical distribution

Definition: Ensuring the products delivery on time and with the expected quality.

	Enterprise Practices	Capability Level				
		Level 1	Level 2	Level 3	Level 4	Level 5
1	The company has a selected number of carriers for all of its transportation needs.	Carriers are changed too often and the decision is based on price only	Carriers are changed with some regularity, and decisions are based on prices and service level	Carriers are not often changed, however, attempts to create partnerships have been done without success	The company usually do business with the same carriers, and negotiate mutual benefits in the short term	The company works closely with selected carriers; finding value in partnering that results in opportunities for mutual benefit
	Current					
	Desired					
	Lean Rationale	• This results in volume discounts and higher priority service due to the higher volumes				
	Evidence					
	Opportunities					
2	Shipping personnel are provided with routing guides for all shipping locations that define the order in which the carriers should be contacted in search of service	Shipping personnel is free to select carriers according to their preferences without any guidelines	Shipping personnel is free to select carriers according to their preferences with some little limitations	Carriers are selected based on management preferences	Carriers are selected based on an agreement between management and shipping personnel	Routing guides are in place, available for every one in the company and are frequently updated
	Current					
	Desired					
	Lean Rationale	• Minimize misjudgement and biased behavior from shipping personal				
	Evidence					
	Opportunities					

should achieve. The tool was designed to rank each of the practices into a SWOT analysis based on the scores provided to the current and desired states. These scores were used to calculate the gap that was used in the decision criteria for the SWOT classification, as illustrated in Table 4.10. This decision criteria is based on the self-assessment tool developed by MIT (2012).

Table 4.10 Decision Criteria for SWOT Analysis, based on MIT (2012)

Characteristic	Current State	Gap	Action
Strengths	>2.0	<1	No improvement required- Maintain
Weaknesses	<=2.0	<1	Raise expectations or accept as it- Low priority
Opportunities	>=2.0	>=1	Determine if possible to improve
Threats	<2.0	>=1	Improve- High priority

Strengths: A best practice is considered strength when the current state is higher than 2 and the gap is 1 or lower. In other words, the best practice is strength when both current and future states are scored 3 or higher in the maturity level and there is no gap between them. That means the company where it wants to be in that best practice no improvements are needed.

Weaknesses: A best practice is considered weak when the current state is 2 or lower and the gap is lower than 1. The best practice is weak when both current and future states are scored 2 or lower in the maturity level and there is no gap between them. That means the company is having a bad performance in that practice and still is satisfied with that performance and do not want to change it. Since every company is different and the practices implemented depend on specific conditions, in this case, the action is to either raise expectations or accept the practice as it. It is possible that a low maturity level in this practice is the best decision for the company based on those specific conditions. Weaknesses are considered low priority.

Opportunities: A best practice is considered opportunity when the current state is 2 or higher and the gap is 1 or higher. In other words, the best practice is an opportunity when the current state is scored 2 or higher in the maturity level and the gap between them is higher 1 or higher. That means the company is having acceptable performance and could improve if they wanted. In this case, the action is to look for alternatives to improve.

Threats: A best practice is considered threat when the current state is lower than 2 and the gap is 1 or higher. In other words, the best practice is threat when

the current state is scored 1 in the maturity level and the gap with the desired state is 1 or higher. This can be translated to show the company has lower performance and wants to improve. The threats identified in this step reflect high priority and require immediate attention.

The final results are presented then in different tables and graphs that allow the respondent to visualize the results in different ways. Table 4.11, for instance, presents several best practices by critical factor and the classification according to the SWOT analysis using sample data. For instance, best practice I.1, that corresponds to the best practice number 1 of the critical factor inventory, had score 1 in the current state and a gap of 2, what make it a threat, requiring immediate attention.

Table 4.11 Critical Factors SWOT classification preview

Critical Factor		Best Practice	Current	Gap	Strength	Weakness	Opportunities	Threats
I. Inventory	I.1	Keep the minimum inventory level required to be able to respond to production. Reliance on safety stock is minimized and safety stock levels are reduced to its minimum (inbound logistics)	1	2				Threats
	I.2	Keep the minimum inventory level required to be able to respond final customer needs. Reliance on safety stock is minimized and safety stock levels are reduced to its minimum (outbound logistics)	2	3			Opportunities	
	I.3	Inventory carrying costs are accurately determined and monitored over time	3	0	strengths			
	I.4	Production planning and inbound logistics are coordinated in order to smooth consumption rate of each item and reduce the possible negative impact of lead times.	2	2			Opportunities	
	I.5	The inbound logistics system must be designed to the specific company needs, considering the required quantities and frequency of use.	1	0		Weaknesses		
	I.6	Training is provided to employees with regard to inventory policies and practices in the company.	1	4				Threats
	I.7	The system that the company uses, either a Manufacturing Execution systems (MES) or Enterprise Resource Planning Systems (ERP), is used to anticipate shortages and trigger warnings to execute contingency plans.	2	0	strengths			
II. Transport	II.1	The company has a selected number of carriers for all of its transportation needs.	1	3				Threats
	II.2	Shipping personnel are provided with routing guides for all shipping locations that define the order in which the carriers should be contacted in search of service	2	1	strengths			
	II.3	When possible, shipments less-than-truckload (LTL) are planned in a way that allows to combine them and pick them up by just one truckload carrier	1	4				Threats
	II.4	In transportation, all the efforts are focused toward minimizing the average delivery time and the variation around that average.	1	3				Threats
	II.5	Efforts are concentrated in reducing overall costs, not only transportation costs	4	0	strengths			

Then, the number of strengths, weaknesses, opportunities and threats by critical factor are summarized and a table that looks like Table 4.12. In this case,

the company has 20 Threats that require immediate attention, 10 opportunities that could help them improve competitiveness, 15 Strengths that should remain equal and 3 Weaknesses that need to be reevaluated.

Table 4.12 SWOT Analysis by Critical Factor

Critical Factor	Strengths	Weaknesses	Opportunities	Threats	Total
I. Inventory	2	1	2	2	**7**
II. Transportation	2	0	0	3	**5**
III. Operations_Administration	1	1	2	0	**4**
IV. Information Systems	2	0	1	1	**4**
V. Warehouse	2	1	3	9	**15**
VI. Forecasting and Scheduling	1	0	1	1	**3**
VII. Packaging	0	0	1	2	**3**
VIII. Supplier Network	5	0	0	2	**7**
Total	**15**	**3**	**10**	**20**	**48**

Then, a gap analysis summary by critical factor is presented and summarizes the current and desired states by critical factor and the gap between them, highlighting the largest gaps, which provides a starting point for planning and improvement. A sample can be visualized in Table 4.13. In that case, Warehouse is the most critical of the critical factor with a current state of 1.40 and desired state of 4.13, and a gap of 2.73 (darkest red).

Table 4.13 Gap Analysis Summary by Critical Factor

Critical Factor	Current	Desired	Gap
I. Inventory	1.71	3.29	1.57
II. Transportation	1.80	4.00	2.20
III. Operations_Administration	1.75	3.00	1.25
IV. Information Systems	2.00	3.75	1.75
V. Warehouse	1.40	4.13	2.73
VI. Forecasting and Scheduling	2.00	3.33	1.33
VII. Packaging	1.33	4.00	2.67
VIII. Supplier Network	2.43	3.29	0.86
Average	**1.80**	**3.60**	**1.80**

The intensity of the red color represents the critical factors with the larger GAP, that is, the darker the red, the most inmediate attention this factor needs.

Finally, a series of graphs are presented providing a visual on the results presented in the previous tables.

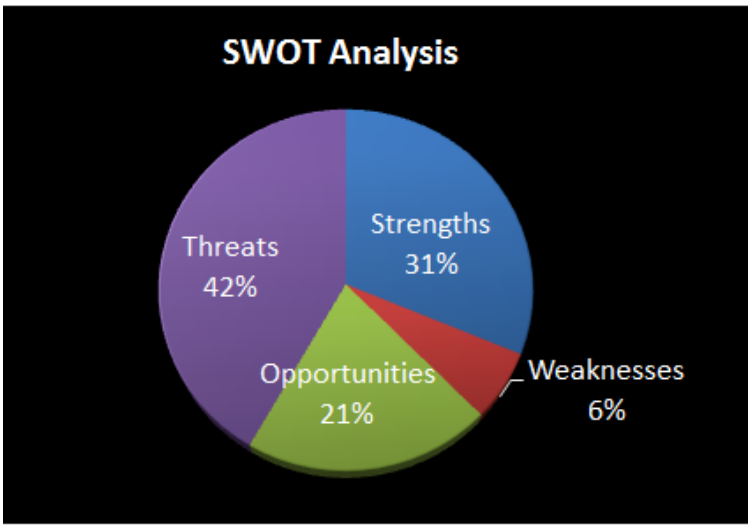
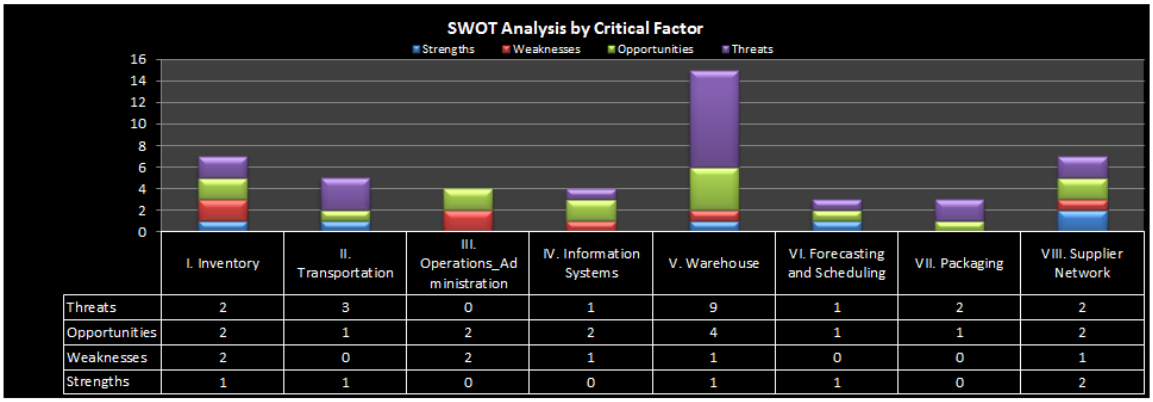


Figure 4.2 SWOT Analysis summary



	I. Inventory	II. Transportation	III. Operations_Administration	IV. Information Systems	V. Warehouse	VI. Forecasting and Scheduling	VII. Packaging	VIII. Supplier Network
Threats	2	3	0	1	9	1	2	2
Opportunities	2	1	2	2	4	1	1	2
Weaknesses	2	0	2	1	1	0	0	1
Strengths	1	1	0	0	1	1	0	2

Figure 4.3 SWOT analysis by Critical Factor

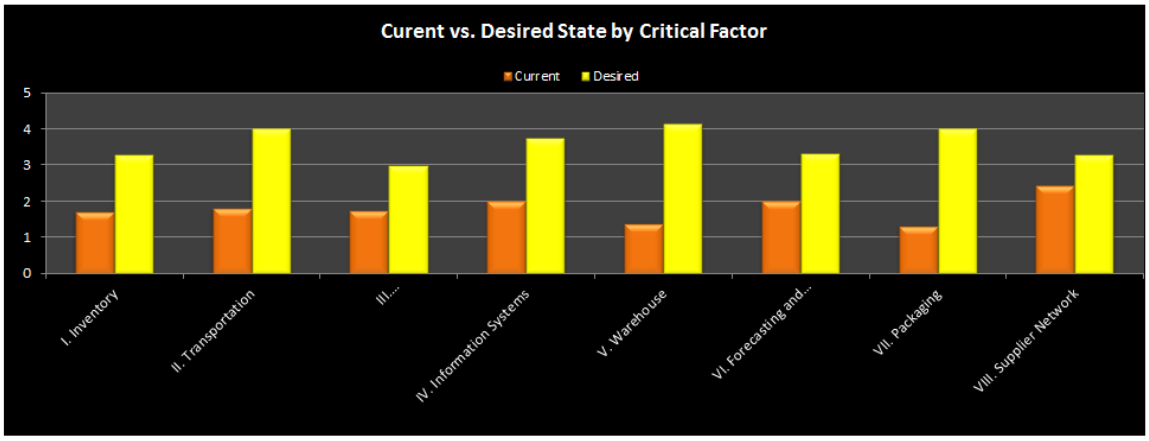


Figure 4.4 Current vs. Desired State by Critical Factor

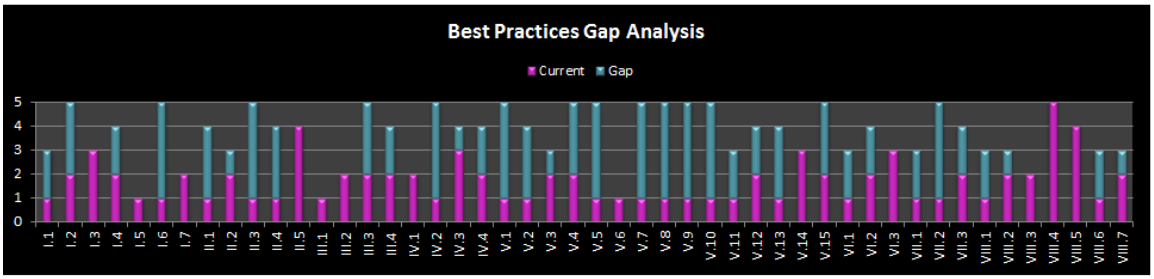


Figure 4.5 Best Practices Gap Analysis

4.2 Step 2: Validation from subject matter experts

After the first draft of the assessment tool was completed, the next step was to send it to subject matter experts to evaluate the quality of the tool in different aspects.

4.2.1 Identifying the Experts

The experts were chosen based on geographical limitation and lean logistics knowledge. 5 experts were identified as potential candidates to evaluate the tool, 2 located in Indianapolis, 2 located in northern Indiana and the last one in the Lafayette, IN area. A first communication was sent out explaining the scope of the research, the type of collaboration that was required and the timeline available. Fortunately, all of the experts contacted expressed their interest in participating in this research project.

4.2.2 Sending the tool through email

The first draft of the assessment tool was sent to the 5 subject matter experts that agreed to participate in the study. Table 4.14 shows the evaluation form that they were required to fill out. The experts judged the tool based on the criteria proposed by the National Quality Council (2009) that was described in the literature review. These criteria are clarity, content accuracy, relevance, content validity, avoidance of bias, appropriateness of language for the target population, and clarity of instructions for completion.

Table 4.14 Evaluation form

Criteria	1- Very Poor	2- Poor	3- Satisfactory	4- Very good	5- Excellent	Comments
Clarity						
Content accuracy						
Relevance						
Content validity						
Avoidance of bias						
Appropriateness of language for the target population						
Clarity of instructions for completion						

Each criterion was scored in a scale of 1 to 5 being 1- very poor, 2- poor, 3– satisfactory, 4- very good and 5- excellent. They were encouraged to write comments for each criterion as well. Only 3 out of 5 subject matter experts participated in the evaluation. Expert 3, however, did not follow the prescribed format and expressed his evaluation in a written paragraph. His comments were classified according to the different criteria and the results are summarized in Table 4.15 and in the next section.

4.2.3 Reviewing and incorporating of feedback

The feedback was collected, analyzed and incorporated into the tool. The findings by criterion are described below:

1. Clarity: Average rate = 3.5, between satisfactory and very good. The experts suggested that for the most part the tool was clear but with some redundancy. Therefore, the researcher reviewed the tool to eliminate redundancies.
2. Content accuracy: Average Rate 3, satisfactory. The experts' comments were positive with regard to the scope of the supply chain topics covered in the tool. Spelling and some grammar mistakes were also highlighted, which were also corrected by the researcher.
3. Relevance: Average rate = 3.5, between satisfactory and very good. Two very important comments were addressed. The first issue was the possibility of existing tools for the same purpose. However, no evidence of lean logistics assessment tools was found during the literature review. Possibly, there are proprietary tools for internal company use only. The goal of the tool developed here is for open use, and was especially designed specifically for SMEs with fewer resources, who can't afford consultants or have the manpower to develop such a tool themselves. The second comment was that lean logistics is not one of the two hot topics in supply chain today. He stated that the hot topics are risk assessment and flexibility to meet changing requirements. According to expert 3, the lack of these hot topics may bias or cloud the respondents' answers. It is not clear how this cloud could happen, because the scope of this tool is clearly defined in the objective and it is only covering lean logistics.

Table 4.15 Summary of expert's quality checks

Criteria	Expert 1	Expert 2	Avg	Comments	Experts 3 Comments
Clarity	4	3	3.5	For the most clear- some redundancy.	
Content accuracy	4	2	3	You cover all of the pieces of a supply chain. Spelling and some grammar mistakes.	
Relevance	3	4	3.5	I'm not sure what the tool would do that is not done by internal tools. Many larger firms already have a tool such as this in use at this time	Lean logistics is a good subject. However, it doesn't seem to include 2 SCM hot topics: risk assessment and flexibility to meet changing requirements.
Content validity	4	4	4	The tool is very complete.	
Avoidance of bias	3	4	3.5		It seems like a lot of questions, hard to hold survey taker's attention that long.
Appropriateness of language for the target population	4	3	3.5	Language is acceptable, few typos to correct.	
Clarity of instructions for completion	4	2	3	Very complete but I am not sure it would be completely filled out in many cases. Did not understand instructions; drop downs in column titles confused me; include drop downs in rating areas.	

4. Content validity: Average rate = 4, very good. The information contained in the tool was valid. The experts stated that the tool was very complete.
5. Avoidance of bias: Average rate = 3.5, between satisfactory and very good. The only concern was the difficulty of holding survey takers' attention due to the length of the evaluation tool. However, the tool is designed for corporate use not to administer blindly to survey respondents. So, the length of the tool should be acceptable.
6. Appropriateness of language for the target population: Average rate = 3.5, between satisfactory and very good. The experts considered the language used appropriate. However, typos were again highlighted, which required a more strict grammar and spelling review.
7. Clarity of instructions for completion: Average rate = 3, satisfactory. The results in this area are a little bit contradictory. One expert stated that the instructions were very clear and complete whereas the other expert stated that he did not understand the option and the layout of the tools was confusing. Even though the score is satisfactory, the researcher reevaluated and redesigned some parts of the tool that could lead to confusion.

Overall, the quality checks resulted in some language, vocabulary and grammar corrections but not important changes to content were incorporated as result of these evaluations. Figure 4.6 summarizes the problems identified by the experts and the actions taken solve those problems.

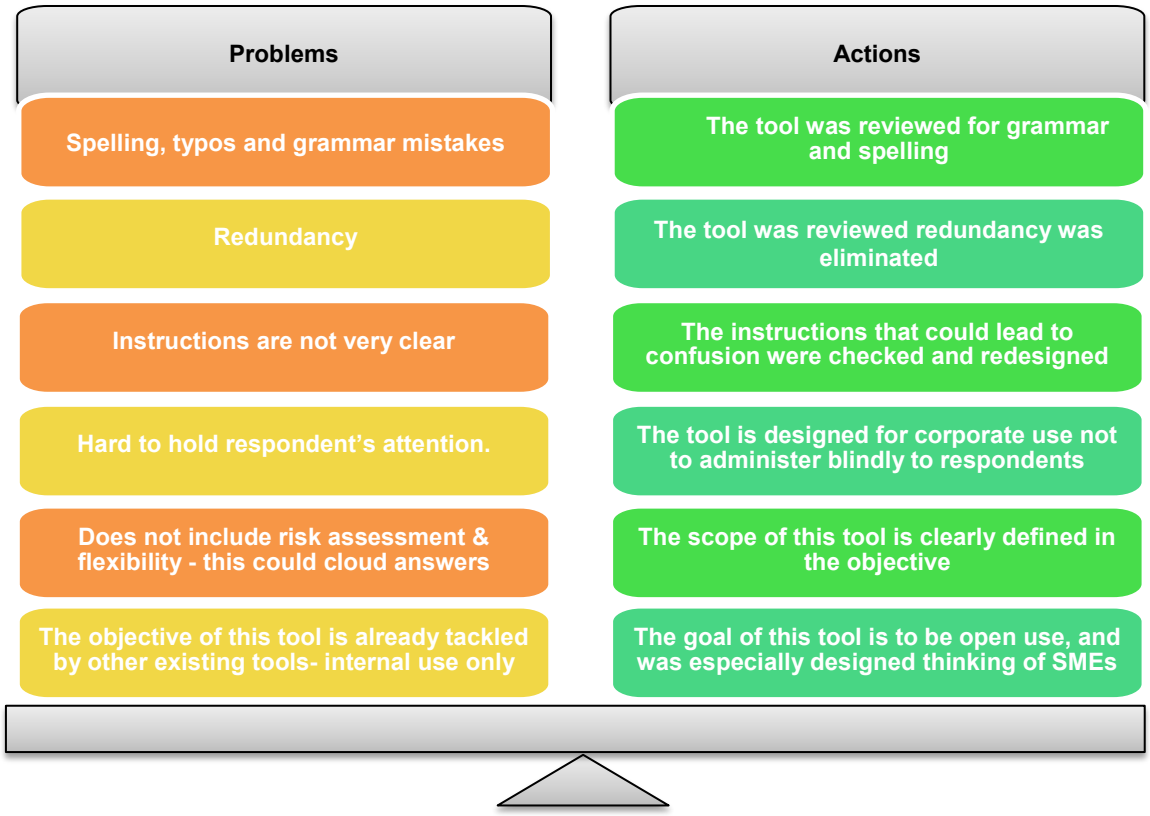


Figure 4.6 Problems vs. Actions

CHAPTER 5. SUMMARY, OUTCOMES AND RECOMMENDATIONS

5.1 Summary

Lean manufacturing is a management technique that has proven to be very effective not only in the manufacturing sector but in many others type of businesses such as service and healthcare. It has been also demonstrated that lean techniques have the ability to adapt from the production system to other areas or departments within the company including logistics. Lean techniques and lean logistics have been reported very useful in LEs. However, the use of these techniques in SMEs has not been broadly documented and published. SMEs are facing challenges in competition that have prompted evolution and adoption of better management techniques. However, SMEs have budget and resources constraints that limit their ability to develop their own tools to analyze management practices. The lack of skills, time and resources results in a narrow view of the company strategy, focusing on operational matters rather that planning. This research project developed a self-assessment tool that t rates key elements and quantifies the maturity of lean logistics operations in SMEs in the manufacturing sector. This tool was developed in two stages. First, a detailed literature review that provided all the required theoretical elements to create the tool. The second step consisted of validation and revision from logistics subject

matter experts. The comments resulting from this evaluation were analyzed and incorporated into the final version of the tool. The validation provided improvements in clarity, accuracy, relevance, validity, avoidance of bias, language use and clarity of instructions.

5.2 Outcomes

The Lean Logistics Assessment Tool Version 1.0 was the result of this research process. This assessment tool was developed to rate the maturity of the current and desired states of lean logistics operations in a specific SME. The model proposes a matrix of strengths, weaknesses, opportunities and threats (SWOT) based on a gap analysis between the current and desired states. The SWOT analysis acts as a roadmap for continuous improvement. This model provides a structured and organized approach to the self-assessment process and acts as a tool to assist the identification of critical barriers to implementing lean logistics. This assessment tool has 48 best practices assigned to 8 critical factors. The goal is to rate each practice twice in a scale from 1 to 5, one time to determine the current state of that practice and the second time to determine the desired state. After the manager has finished evaluating the 48 practices, a SWOT analysis based on the answers provided is generated, classifying each of the practices according to categories defined in Table 4.10 Decision Criteria for SWOT Analysis. When implemented in a SME, this self-assessment tool provides managers a detailed overview of the current lean logistics practices in the company. This self-assessment can be considered a diagnostic tool that

provides SMEs the opportunity to initiate transformations, prioritizing on the threats and weaknesses resulting from the SWOT analysis. This diagnostics is very beneficial for SMEs because it helps them to undertake a more proactive approach rather that reactive. The goal is to give SMEs a tool that can result in a better understanding of the company and also to provide the whole picture of the lean logistics practices that are being implemented. It is impossible to initiate successful improvement initiatives without knowing the strengths and threats faced by the company.

5.3 Recommendations and Future Work

This research project represents the initial steps to developing a self-assessment tool that could eventually be used for managers in SMEs. Additional work is required in order to continue working towards this goal:

- ✓ Design a web application of the tool. This would facilitate the use of the tool by eliminating the use of paper or excel files that could be overwhelming or frustrating. With a more user friendly tool it is possible to have higher response rates.
- ✓ Conduct field trials in a broad range of SMEs to determine if there are too many questions. The 48 best practices that are being evaluated are the result of an in depth literature review. It might seem like 48 practices are too many practices but they comprised all the lean logistics best practices.
- ✓ Design a multiple respondent tool. The Version 1.0 is a single respondent self-assessment tool that is intended to be completed by the logistic manager.

However, if the objective is to have multiple employees participating in the assessment, a second version of the tool would be required.

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