Chapter 5

Assessment and Comparison of the RSSC using Decision Models*

5.1 Introduction

The objective of this Chapter is to analyze key criteria, their impact on automotive organization performance maturity and analysis of different mitigation strategies. To achieve aforesaid objectives it is realize to use multi criteria decision making techniques. Analytical Hierarchy Process (AHP) methodology is envisaged in this context to enrich the evaluation of the secure supply chain which includes supply chain security, supply chain risk and supply chain risk & security in the Indian automotive industries context.

This Chapter starts from a study based on key factors identified (i.e. factor analysis, Chapter 4) and extended for multi criteria decision making analysis using AHP. AHP as a methodology (i.e. using expert choice as a tool) used to analyze a hierarchical model of Secure Supply Chain for 7 automotive industries. Model has been developed to identify the weightages of each criterion’s (i.e. factors), comparison of maturity level of industries and evaluation of alternative solution methodology.

AHP methodology is selected in the present case for assessing and comparing the secure supply chain factors, prioritization of best alternatives (e.g. selection of automotive industries based on pairwise comparison and identify development opportunities based on secure supply chain maturity level).

The Analytic Hierarchy Process (AHP) based RSSC is a relatively less used approach for secure supply chain (i.e. risk & security) assessment. The AHP provides a flexible and easily understood way to analyze supply chain risks.

This study is carried out for 7 automotive industries, hence opportunity to evaluate all factors for comparative studies of these factor and further evaluation based on various scenarios.

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*Part of this chapter is accepted as “Analytic Hierarchy Process to Assess Supply Chain Risk and Security Management”, Best Practices in Supply Chain Management (BPSCM-2012), Bhuvneshwar, India; 22nd-23rd Nov 2012.
In this Chapter, following major issues are covered based on aforesaid problem understanding:

a) Identification of important factors specific to industries, challenges, their importance and impact on industry maturity

b) Robust and secure supply chain performance modelling on AHP modelling which help in comparative assessment of automotive industries

c) Critical evaluation of mitigation strategies for each industry

d) What if scenarios analysis to support managers to avoid RSSC challenges and designing robust performance model. The implications for business of the likely changes to secure supply chain dynamics in the upcoming years.

Flow chart for Chapter is discussed in Figure 5.1 which explicitly shows the flow of this Chapter and methodology as a subset of overall research methodology.

Figure 5.1: Flow Chart of the Process
5.2 Review of Literature and Justification for AHP

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. Rather than prescribing a "correct" decision, the AHP helps people to determine one. Based on mathematics and human psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then (Cho et al., 2012; Rao, 2013). The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education (Johnson, 2009). The Analytic Hierarchy Process (AHP) is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered (Xue-zhen, 2007).

AHP has been recommended by many authors, for ex. Zahedi 1986; Wasil et al. 1989; Shim, 1989; Vargas, 1990; Saaty and Forman, 1992; Forman and Gass, 2001; Kumar and Vaidya, 2006; Omkarprasad and Sushil, 2006; Ho, 2008; Liberatore and Nydick, 2008). The oldest reference have been found dates from 1972 (Saaty 1972). Analytical Hierarchy Process (AHP) methodology is envisaged in this research context to enrich the comparative evaluation of the robust and Secure Supply Chain performance (comprising risk and security) in the Indian automotive industries scenario. AHP methodology can optimize the selection of risk and security performance measure followed by relevant choices for decision making with implication. AHP has strength that one level it tries to identify the factors of the secure supply chain for robust performance and at more important level to evaluate these factors and alternative industries based on their current SSC maturity level. AHP is selected for study as it is most robust, widely acceptable and scientific among all MCDM techniques (Satty, 2000; Rao, 2013).

It is envisaged that it may be expedient to evolve the AHP based RSSC framework to impart decision making at various levels. These levels need to be well supported by literature and expert views. Present evaluation system for supply chain business strategy is more aligned with cost based measure, however RSSC based system consist of key unique criteria
and mitigation strategies will help industries to achieve the individual benchmark and standards with best cost vs. security trade off.

AHP is a decision-making tool that can help describe the general decision operation by decomposing a complex problem into a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives (Saaty, 1990). AHP can be used in making decisions that are complex, unstructured, and contain multiple attributes (Partovi, 1994). The decisions that are described by these criteria do not fit in a linear framework; they contain both physical and psychological elements (Mian and Dai, 1999).

Analytical Hierarchy Process (AHP) is justified, which facilitates in the entire critical decision making and has the potential to improve existing system of evaluation and decision making. AHP provides a method to connect that can quantify the subjective judgment of the decision maker in a way that can be measured. Data collection, AHP Process and Data Analysis is discussed in next section in this context.

Table 5.1 shows the details of select research on AHP.
## Table 5.1: Select Research Studies on Analytical Hierarchy Process

<table>
<thead>
<tr>
<th>Author, Years</th>
<th>Paper Title</th>
<th>Journal</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saaty, T.L, 1980</td>
<td>The Analytic Hierarchy Process. Planning’</td>
<td>McGraw-Hill, New York</td>
<td>AHP theory has been formulated and suggested. (Book). AHP is a decision-making tool that can help describe the general decision operation by decomposing a complex problem into a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives.</td>
</tr>
<tr>
<td>Saaty TL, 1994</td>
<td>Fundamentals of decision making and priority theory with the analytic hierarchy process</td>
<td>Pittsburgh –RWS Publications</td>
<td>Fundamentals of decision making and priority theory with the analytic hierarchy process are discussed.</td>
</tr>
<tr>
<td>Triantaphyllou and Mann, 1995</td>
<td>Using The Analytic Hierarchy Process For Decision Making In Engineering Applications: Some Challenges</td>
<td>Inte. Journal of Industrial Engineering: Applications and Practice</td>
<td>Examines some of the practical and computational issues involved when the AHP method is used in engineering applications.</td>
</tr>
<tr>
<td>Hauser and Tadikamalla, 1996</td>
<td>The Analytic Hierarchy Process in an uncertain environment: a simulation approach</td>
<td>European Journal of Operation Research</td>
<td>Author demonstrates that levels of confidence can be developed, expected weights can be calculated and expected ranks can be determined. It will also be shown that the simulation approach is far more revealing than traditional sensitivity analysis.</td>
</tr>
<tr>
<td>Fuller and, Carlsson, 1996</td>
<td>Fuzzy multiple criteria decision making: Recent developments</td>
<td>Fuzzy Sets and Systems’</td>
<td>Fuzzy MCDM has been proposed in multiple supply chain direction. Although with the help of fuzzy set theory a number of innovations have been made possible; the most important methods are reviewed and a novel approach interdependence in MCDM is introduced.</td>
</tr>
<tr>
<td>Liu, et al, 1999</td>
<td>AHP based decision modeling in CAPP development tools</td>
<td>International Journal of Advanced Manufacturing Technology</td>
<td>Discussed process planning decision modeling as a main barrier in the research on CAPP development tools, and also a bottleneck hampering the process of pragmatisation and commercialization of CAPP.</td>
</tr>
<tr>
<td>Karsak and Tolga, 2001</td>
<td>Fuzzy multi-criteria decision-making procedure for evaluating advanced manufacturing system investment</td>
<td>International Journal of Production Economics</td>
<td>A fuzzy decision algorithm was proposed to select the most suitable advanced system (AMS) alternative from a set of mutually exclusive alternatives. Both economic evaluation criterion and strategic criteria such as flexibility, quality improvement, which are not quantitative in nature, are considered for selection.</td>
</tr>
<tr>
<td>Mikhailov, 2004</td>
<td>Evaluation of services using a fuzzy analytic hierarchy process</td>
<td>Applied Soft Computing</td>
<td>A new approach for tackling the uncertainty and imprecision of the service evaluation process was proposed. Identifying suitable service offers, evaluating the offers and choosing the best alternatives are activities that set the scene for the consequent stages in negotiations and influence in a unique manner the following deliberations.</td>
</tr>
<tr>
<td>Author, Years</td>
<td>Paper Title</td>
<td>Journal</td>
<td>Contribution</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td>---------</td>
<td>--------------</td>
</tr>
<tr>
<td>Thomas and Talluri, 2008</td>
<td>A Supply Risk Reduction Model Using Integrated Multicriteria Decision Making</td>
<td>IEEE Transaction Engineering Management</td>
<td>Developed a framework for risk assessment based on various categories and types of risks. Author proposes a combination of analytic hierarchy process and goal programming as a decision tool for supplier selection in the presence of risk measures and product life cycle considerations. The efficacy of the model is tested at a mid-sized automotive supplier and managerial implications are discussed.</td>
</tr>
<tr>
<td>Johnson et al., 2009.</td>
<td>Multi criteria-based customer-focused vendor selection through the analytic hierarchy processes</td>
<td>Int. J. of Procurement Management</td>
<td>Multi criteria-based customer-focused vendor selection through the analytic hierarchy processes was implemented.</td>
</tr>
<tr>
<td>Joshi, 2012</td>
<td>A Delphi-AHP-TOPSIS based benchmarking framework for performance improvement of a cold chain</td>
<td>Expert Systems with Applications</td>
<td>Developed a benchmarking framework that evaluates the cold chain performance of a company, reveals its strengths and weaknesses and finally identifies and prioritizes potential alternatives for continuous improvement.</td>
</tr>
<tr>
<td>Dong et al., 2012</td>
<td>A framework for measuring the performance of service supply chain management</td>
<td>Computers &amp; Industrial Engineering</td>
<td>Developed a framework of service supply chain performance measurement for hotels. And to prioritize service supply chain performance measurement indicators to improve service supply chain performance, a methodology based on the extent fuzzy analytic hierarchy process is stressed.</td>
</tr>
<tr>
<td>Ghosh et al., 2012</td>
<td>An effective AHP-based metaheuristic approach to solve supplier selection problem</td>
<td>Int. J. of Procurement Management</td>
<td>Evaluate the supplier selection problem based on electing the best supplier from a group of pre–specified candidates. This was identified as a multi–criteria decision making (MCDM), and is proportionately significant in terms of qualitative and quantitative attributes.</td>
</tr>
<tr>
<td>Manas et al., 2012</td>
<td>A heuristic method for supplier selection using AHP, entropy and TOPSIS</td>
<td>Int. J. of Procurement Management</td>
<td>In this study author recommend that decision support can have a huge positive impact in the processes in procurement. Authors apply a proposed heuristic method (AET) as a combination of AHP (analytical hierarchy procedure), entropy, and technique for order preference by similarity to an ideal solution (TOPSIS) to select the best supplier.</td>
</tr>
<tr>
<td>Rao, 2013</td>
<td>Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods</td>
<td>Springer Series in Advanced Manufacturing</td>
<td>Author suggested and designed to reflect the way people actually think, AHP continues to be the most highly regarded and widely used decision making method.</td>
</tr>
</tbody>
</table>
5.3 Data Collection for AHP

In this research, exclusive list of 14 validated factors responsible for secure supply chain has been used to develop a survey questionnaire for the present study.

Questionnaire development and pre testing has been done in accordance with the guidelines by Forza (2002). Pilot questionnaire was distributed to 20 people colleagues (5), Sr. experts from industry (5), and target respondents (10).

Details of Questionnaire development stages were same as highlighted in Chapter 3.

In part 2 of the study, an attempt is made to understand the impact of these factors in automotive industries, their competitive performance and mitigation. In survey 2 studies, Initially 49 senior professional and practitioners were approached to collect data for 7 automotive industries. These respondents were selected specifically from the top management labels/ retired persons having served in different auto companies for more than 20 years. In order to get the unbiased opinion majority of the persons were recently retired senior professional who has worked more than 3 organizations. 33 Responses received from the respondents after mild reminder cum follow ups. After initial validation, 31questionnaires were found valid for the analysis since two questionnaires was found incomplete. Response rate of 65% is achieved. Seven key automotive industries (same as selected in study 1) are considered for this study which is explained in another section of this Chapter. Researcher personally collected the data by contacting the respondents. Questionnaire was complied while the researcher explaining and clarifying doubt and difficulties.

In applying AHP to benchmarking, (Partovi, 1994) describes the process in three broad steps: a) The description of a complex decision problem as a hierarchy, b) The prioritization procedure, and c) The calculation of results. Similarly various other authors (from Satty, 1994; Ho et al., 2006; Sharma et al., 2008; Johnson, 2009; Dong et al., 2012) suggested AHP process from different industry context which is complied in next section in this research context.

5.4 Data Analysis and AHP Process

More and more researchers are realizing that AHP is an important generic method and applying it to various manufacturing areas. In addition to the wide application of AHP in manufacturing areas, recent research and industrial activities of applying AHP on other selection problems are also quite active. AHP has thus been successfully applied to a diverse
array of problems. A schematic representation of the methodology is given in Figure 5.3 (Ho et al., 2006, Sharma et al., 2008).

Since the comparisons are carried out through personal or subjective judgments, some degree of inconsistency may be occurred. To guarantee the judgments are consistent, the final operation called consistency verification (Satty, 1994), which is regarded as one of the most important advantages of AHP, is incorporated in order to measure the degree of consistency among the pair-wise comparisons by computing the Consistency Ratio (CR). A ratio of 0.10 or less is considered acceptable for CR (Satty, 1994; Ho et al., 2006; Johnson, 2009; Dong et al., 2012). Once all pair-wise comparisons are carried out at every level, and are proved to be consistent, the judgments can then be synthesized to find out the priority ranking of each criterion and its attributes (Cho, et al., 2012).

Figure 5.2 shows the demographic profile of the respondents participate in this survey and provide inputs for AHP study in given questionnaire format.

![Figure 5.2: Demographic Profile Of Respondents For AHP Study](image)

Expert choice 2000 as a tool used for this study. Expert Choice helps organizations to handle the complexity of important decisions. Expert choice is the popular software of AHP used by many leading organizations like IBM, Dell, Samsung and NASA (Rao, 2013). Sensitivity analysis of expert choice is the powerful aid, from which different scenario can be analyzed without changing the actual value (Sharma et al., 2008).

Data analysis for AHP based data collection is an important step for this research. This is carried out in following key direction:

a) Understand the impact of key factors in 7 automotive industries
b) Ranking and comparative analysis of industries

c) Mitigation strategy to select the right strategy for industries

d) Sensitivity Analysis (i.e. What if scenario analysis) to evaluate various real life scenario and its implication to managers

The present research proposes a robust and secure supply chain pain areas & criteria’s and alternative solution methodology to minimize the impact by using AHP as a multi-criteria decision making approach. This approach can assist experts in critical decision-making and justification (Pani et al., 2012). AHP is selected for robust and secure supply chain context due to its ability to provide solution through scientific way. Analytical Hierarchy Process (AHP) is a method for formalizing decision making where there are a limited number of choices but each has a number of attributes and it is difficult to formalize some of those attributes.

This research section is executed in two phases. In first phase expert choice (EC) (www.expertchoice.com) software that implements the AHP, as proposed by Saaty, 2000 is used to develop the model (e.g. automotive industries evaluation for Secure Supply Chain model and RSSC mitigation strategy plan model. Expert choice as a tool used to facilitate AHP study and validated by java based AHP tool (developed for this research based on AHP methodology) for which is a custom solution developed for this research. Details of this Java based AHP tool are not disclosed in this study, rather study focused more on results. Next sub sections are describing this methodology in detail considering key steps in consideration.

The AHP consists of five main operations (Modified and Appended from Satty, 1994; Ho et al., 2006; Sharma et al., 2008; Johnson, 2009; Dong et al., 2012) as shown in Figure 5.3.

(i) Hierarchy Structure

(ii) Pairwise comparison

(iii) Synthesization

(iv) Consistency verification and

(v) Development of overall Priority Ranking
5.4.1 Develop Hierarchy Structure

AHP is a method of breaking down a complex, unstructured situation into its components parts, arranging these parts or judgments on the relative importance of each variable, and synthesizing the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation (Saaty, 1990).

A problem is put into a hierarchical structure with
a) Level-I reflecting the overall goal or focus of the decision.
b) Level-II contains factors or criteria for the decision.
c) Level-III contains sub-factors, and
d) Level-IV contains the decision options.
The prioritization process is accomplished by assigning a number from a scale developed by (Saaty, 1990) to represent the importance of the criteria. A matrix with pair-wise comparisons (Kumar and Vaidya, 2006) of these attributes provides the means for calculation.

An AHP hierarchy is a structured means of describing the problem at hand. It consists of
a) An overall goal,
b) A group of options or alternatives for reaching the goal, and

c) A group of factors or criteria that relate the alternatives to the goal.

Figure 5.4 visualize the hierarchy with the goal at the top, the alternatives at the bottom, and
the criteria filling up the middle (Adapted and modified from Saaty and Forman, 1992). In
such diagrams, each box is called a node. The boxes descending from any node are called its
children. The node from which a child node descends is called its parent. Applying these
definitions to the diagram below, the criteria are children of the Goal, and the Goal is the
parent of each of the criteria (Dong et al., 2012). Each Alternative is the child of each of the
Criteria, and each Criterion is the parent of each Alternatives. In practice, many Criteria have
one or more layers of sub criteria (Ho, 2008). These are not shown in this simplified diagram.
Also, to avoid clutter in AHP diagrams, the lines between the Alternatives and Criteria are
often omitted or reduced in number (Sharma et al., 2008; Johnson, 2009). Regardless of any
such simplifications in the diagram, in the actual hierarchy each Alternative is connected to
every one of its covering criteria—the lowest-level criteria, sub criteria, etc. of which it is a
child. In most cases the criteria are further broken down into sub criteria, sub-sub criteria,
and so on, in as many levels as the problem requires.
The design of any AHP hierarchy will depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the process (Johnson, 2009; Dong et al., 2012). As the AHP proceeds through its other steps, the hierarchy can be changed to accommodate newly-thought-of criteria or criteria not originally considered to be important; alternatives can also be added, deleted, or changed.

5.4.1.1 Identification of Key Factors

In this stage, a criterion (i.e. factors) has been identified flowing research methodology steps from item identification till factor extraction using factor analysis (refer Chapter 3 and 4). The 14 enablers (i.e. factors) of Robust and Secure Supply Chain (RSSC) are being identified through in-depth literature review, consultation with experts, discussions with eminent industrialists and finally after adapted a series of statistically validated processes and tools viz. data collection (201 valid respondents), data analysis (EFA) and validation through CFA models. This entire exercise is detailed in Chapter 4. These enablers (inputs) are used for critical decision making using AHP in the present Chapter. Further, data is collected for AHP based multicriteria decision making. Data is collected for pairwise comparison of automotive industries based on key criteria and key business mitigation strategies.

5.4.1.2 Measurement Scale

The decision makers need to break down complex multiple criteria decision problems into its component parts of which every possible attributes are arranged into multiple hierarchical levels (Karsak and Tolga, 2001). After that, the decision makers have to compare each cluster in the same level in a pair-wise fashion based on their own experience and knowledge (Fuller and Carlsson, 1996; Rao, 2013). For instance, every two criteria in the second level are compared at each time with respect to the goal, whereas every two attributes of the same criteria in the third level are compared at a time with respect to the corresponding criterion. To compare criteria and sub criteria nine point scale (Satty, 1994) can be used (Table 5.2).
Each branch is then further divided into an appropriate level of detail. At the end, the iteration process transforms the unstructured problem into a manageable problem organized both vertically and horizontally under the form of a hierarchy of weighted criteria (Ghosh et al., 2012). By increasing the number of criteria, the importance of each criterion is thus diluted, which is compensated by assigning a weight to each criterion.

5.4.1.3 Hierarchy Structure for RSSC

The model of the present research incorporates fourteen supply chain risk & security factors (Please refer detail description provided in Chapter 3). First model of the present research incorporates following important RSSC factors in 7 automotive industries (1) Supplier (2) Demand (3) Manufacturer, (4) Distributor (5) Socio-economic (6) Geo-political (7) Data or information or IT, (8) Catastrophic (9) Theft or Shrinkage, (10) Customer Attrition, (11) Multiple coordination (12) Procedural (13) Training, and (14) personnel. Seven different automotive industries are considered to evaluate their maturity level.

Figure 5.5 depicts the hierarchy structure of fourteen criteria’s and 7 alternative organizations. The decision hierarchy involves a goal, objectives and alternatives of choice, pair wise judgments on the elements of the hierarchy, with respect to their parent element, to derive priorities, and then synthesize the priorities into an overall result are carried out. In next stage hierarchy structure is created in expert choice and survey data is translated into the right format. Various models and scenario (4 type of what if scenario analysis) were created to synthesize the results.

<table>
<thead>
<tr>
<th>Intensity of importance</th>
<th>Name</th>
<th>Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two activities contribute equally to the objective</td>
</tr>
<tr>
<td>3</td>
<td>Weak importance of one over another</td>
<td>Experience and judgement slightly favour one activity over another</td>
</tr>
<tr>
<td>5</td>
<td>Essential or strong important</td>
<td>Experience and judgement strongly favour one activity over another</td>
</tr>
<tr>
<td>7</td>
<td>Demonstrated importance</td>
<td>An activity is favoured very strongly over another; its dominance demonstrated in practice</td>
</tr>
<tr>
<td>9</td>
<td>Absolute importance</td>
<td>The evidence favouring one activity over another is of the highest possible order of affirmation</td>
</tr>
</tbody>
</table>

Table 5.2: Thomas Saaty’s Nine-Point Scale (Adapted from Saaty, 1994)
Figure 5.5: The Decision Hierarchy Structure for Supply Chain Solution Strategy
5.4.2 Pairwise Comparison

Pair-wise comparisons are used to determine the relative importance of each alternative in terms of each criterion (Triantaphyllou and Mann, 1995; Johnson, 2009). According to (Satty, 1994) AHP involves the comparison in pairs of the elements of the constructed hierarchy in each period. The aim is to set their relative priorities with respect to each of the elements at the next higher level. The elements (a_{ij}) will satisfy the following conditions:

\[ a_{ij} = 1 / a_{ji} \quad \text{and} \quad a_{ii} = 1 \quad \text{with} \quad i, j = 1, 2, \ldots, \text{n} \]

in the comparison matrix, \( a_{ij} \) can be interpreted as the degree of preference of \( i \)-th criteria over \( j \)-th criteria.

In this approach the decision-maker has to express his opinion about the value of one single pair wise comparison at a time ((Kleindorfer and Wassenhove, 2004; Pani et al., 2012). In this research two different AHP models for RSSC study are considered which are useful in different levels. For the both the model hierarchy structure is developed to execute the pairwise comparison.

Figure 5.6 shows weightages among criteria and alternatives with respect to supplier risk. It is visible from the analysis that company C has the highest score, which indicates that this organization is practicing necessary supply chain security risk mitigation tools and technologies which can be considered as Robust Supply Chain.

The criteria information risk and security has highest priority weightage, appearing as main concern of the organization.

![Figure 5.6: Pair Wise Comparison of Criteria’s And Alternatives](image-url)
Figure 5.7 shows the alternative weightages based on pairwise comparison. It is observed that out of seven organizations (due to confidentiality name of the automotive industries are not depict in this Figure) performance of organization C is most robust and achieved highest level of maturity. Organization B set at the lowest level. Consistency is checked based on methodology suggested by various researchers (Saaty et al, 1970; Lane and Verdini 1989; Tummala and Wan 1994; Alonso and Lamata, 2006) etc.

5.4.3 Synthesization

Initially key dimensions were evaluated and compared for 7 automotive industries identified. Analysis and comparative assessment of various automotive industries on RSSC criteria is discussed in next sub section.

5.4.3.1 Comparative Analysis of Automotive Industry on RSSC Criteria

RSSC Based on respondents inputs received on comparison of each criterion, Table 5.3 of criteria’s (e.g. factors) weights has been calculated through AHP methodology. Expert choice as a software used to validate the results after manual calculation. This is important from organizational perspective to give appropriate focus on each criterion on different secure supply chain scenario.
Table 5.4 shows more descriptive and gives weight matrix to criteria’s versus each alternative. This is useful to focus on individual organization and customize strategies for specific industry needs. What if scenario analysis is conducted to understand the reason of their performance variation and discussed in next sub section. This weight matrix helps each organization to decide ranking of each criteria important for their RSSC maturity. For example, Manufacturing risk and security, Information risk and security, and Catastrophic risk are the most lagging criteria for Organization A whereas demand is the most lagging criteria which need greater attention for it development. Overall information risk and security as criteria listed in top followed by multitier coordination (Table 5.4). Socio economic and customer attrition are least important criteria for all the organizations. This detail matrix indicates specific criteria to organization for their performance improvement.

<table>
<thead>
<tr>
<th>Criteria’s</th>
<th>Alternatives (Weights)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Org A</strong></td>
<td><strong>Org B</strong></td>
</tr>
<tr>
<td>SCS - Supplier</td>
<td>0.756</td>
</tr>
<tr>
<td>SCS - Demand</td>
<td>0.500</td>
</tr>
<tr>
<td>SCS - Manufacturing</td>
<td>1.000</td>
</tr>
<tr>
<td>SCS - Distribution</td>
<td>0.798</td>
</tr>
<tr>
<td>SCS - Socio-Economic</td>
<td>0.752</td>
</tr>
<tr>
<td>SCS - Geo Political</td>
<td>0.800</td>
</tr>
<tr>
<td>SCS - Information</td>
<td>1.000</td>
</tr>
<tr>
<td>SCS - Catastrophic</td>
<td>1.000</td>
</tr>
<tr>
<td>SCS - Theft or Shrinkage</td>
<td>0.667</td>
</tr>
<tr>
<td>SCS - Customer Attrition</td>
<td>0.667</td>
</tr>
<tr>
<td>SCS – Multitier Coordination</td>
<td>0.679</td>
</tr>
<tr>
<td>SCS - Procedural</td>
<td>0.798</td>
</tr>
<tr>
<td>SCS - Training</td>
<td>0.752</td>
</tr>
<tr>
<td>SCS - Personnel</td>
<td>0.935</td>
</tr>
</tbody>
</table>

Table 5.3: Composite Priority Weights for Critical RSSC Success Factors

<table>
<thead>
<tr>
<th>Robust and Secure Supply Chain related to</th>
<th>Criteria</th>
<th>Local Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier Criteria</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Demand Criteria</td>
<td>0.051</td>
<td></td>
</tr>
<tr>
<td>Manufacturing Criteria</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>Distribution Criteria</td>
<td>0.095</td>
<td></td>
</tr>
<tr>
<td>Socio-Economic Criteria</td>
<td>0.041</td>
<td></td>
</tr>
<tr>
<td>Geo Political Criteria</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Information Criteria</td>
<td>0.112</td>
<td></td>
</tr>
<tr>
<td>Catastrophic Criteria</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Theft or Shrinkage Criteria</td>
<td>0.095</td>
<td></td>
</tr>
<tr>
<td>Customer Attrition Criteria</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>Multitier Coordination Criteria</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>Procedural Criteria</td>
<td>0.093</td>
<td></td>
</tr>
<tr>
<td>Training Criteria</td>
<td>0.083</td>
<td></td>
</tr>
<tr>
<td>Personnel Criteria</td>
<td>0.095</td>
<td></td>
</tr>
</tbody>
</table>
5.4.4 Verify the consistency of decision

Consistency verification in AHP is very necessary as consistency refers to (Ranja et al., 2012; Rao, 2013). AHP calculates a consistency ratio to reflect the consistency of decision maker’s judgment during the evaluation phase. The consistency ratio in both the decision matrix and in pair-wise comparison matrices could be calculated with the equation:

\[ CI = (\lambda_{\text{max}} - N) / (N-1); \]

\[ CR = CI / RCI \]

Where 
- CI = Consistency Index
- CR = Consistency Ratio
- RCI = Random Consistency Index
- N = Number of elements

Table 5.5: Random Consistency Index (RCI)

<table>
<thead>
<tr>
<th>Number of elements</th>
<th>Random consistency index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.58</td>
</tr>
<tr>
<td>4</td>
<td>0.90</td>
</tr>
<tr>
<td>5</td>
<td>1.12</td>
</tr>
<tr>
<td>6</td>
<td>1.24</td>
</tr>
<tr>
<td>7</td>
<td>1.32</td>
</tr>
<tr>
<td>8</td>
<td>1.41</td>
</tr>
<tr>
<td>9</td>
<td>1.45</td>
</tr>
<tr>
<td>10</td>
<td>1.51</td>
</tr>
</tbody>
</table>

Table 5.5 refers the random consistency index which helps in evaluating model consistency. The closer the in consistency index is to zero, the greater the consistency. The consistency ratio should be lower than 0.10 to accept the AHP result as consistent (Satty, 1994; Johnson, 2009). If it is found that the consistency ratio exceeds the 0.10 limit, the decision makers should review and revise the pair-wise comparisons (Johnson, 2009, Rao, 2013). In this RSSC AHP model consistency was found within the limit. Consistency ratio of 0.03 is obtained, which was acceptable as per above arguments by different authors.

The next section presents a step by step process for data collection along with hierarchy based solutions.

5.4.5 Development of Priority Ranking

In this section result of AHP based robust and secure supply chain models are discussed. It is been investigated the subject of secure supply chain for automotive manufacturing industries. A scheme of classifying the various sources of RSSC has been
developed. RSSC factors (based on Chapter 4) significant to supply chain are identified and incorporated in this assessment. Result analysis is shared after each model with detail explanation for example; information risk and security is identified as a critical impacting factor (rank 1) which is a major source of concern with maximum rating. Description of each model is provided in next sub section.

Figure 5.8 shows overall result analysis to rank various automotive industries, provide opportunity to benchmark and further improvement.

![Figure 5.8: Alternative Selection and Synthesis Based on Pair wise Comparison](image)

In this research, organization C tops in the list whereas Organization B is in the bottom. This list helps organization to adopt best practice and enable them to improve their performance. This methodology is useful for industry practitioners and researcher to develop RSSC maturity level for automotive industries. This section briefly explain and provided insight on which industry and factors need attention, however how much improvement is required that will be evaluate through what if sensitivity analysis. It is discussed in next sub section.

In next section, detail sensitivity analysis is carried out to identify the impact of change in each criteria (dimensions) on organization RSSC performance. This will be important for managers, and practitioners to identify the improvement opportunity in existing RSSC capability of organization. Further, to mitigate the identified risk and security issues various alternative mitigation strategies were suggested. Detail sensitivity analysis has been carried out to understand the impact of each strategy from different perspective.
5.5 Sensitivity Analysis for Automotive Industry and key Dimensions

Sensitivity Analysis is carried out to understand the results of comparative automotive industry analysis in more explicit manner. This helps in identifying and development of key criteria for that industry with threshold limit. In sensitivity analysis, the input data are slightly modified in order to observe the impact on the results. If the ranking does not change, the results are said to be robust (Satty, 2000; Samvedi et al., 2013). The sensitivity analysis is best performed with an interactive graphical interface. Expert Choice allows different sensitivity analyses, where the main difference is the various graphical representations (Mikhailov and Tsvetinov, 2004; Ghosh et al., 2012). Sensitivity analysis is a way to predict the outcome of a decision if a situation turns out to be different compared to the key prediction(s). Sensitivity Analysis is used by various researcher (Satty, 2000; Mikhailov and Tsvetinov, 2004; Ghosh et al., 2012; Samvedi et al., 2013) for various application. It is commonly used from different analysis perspective, and recommended (Mikhailov and Tsvetinov, 2004; Ghosh et al., 2012) for 4 sensitivity analysis procedure / techniques used in this research. This is presented in Table 5.6.

Table 5.6: Sensitivity Analysis for AHP

<table>
<thead>
<tr>
<th>Sensitivity Analysis</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance sensitivity</td>
<td>Satty, 2000; Ghosh et al., 2012,</td>
<td>The Performance sensitivity shows how the alternatives perform with respect to all objectives as well as overall.</td>
</tr>
<tr>
<td>Dynamic Sensitivity</td>
<td>Satty, 2000; Mikhailov and Tsvetinov, 2004</td>
<td>Dynamic sensitivity analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices.</td>
</tr>
<tr>
<td>Gradient Sensitivity</td>
<td>Ghosh et al., 2012; Rao, 2013</td>
<td>The Gradient sensitivity shows &quot;key tradeoffs&quot; when two or more alternatives intersect each other. This is even more important if the intersection is close to the objectives priority.</td>
</tr>
<tr>
<td>Head to Head Sensitivity</td>
<td>Johnson, 2009; Samvedi et al., 2013</td>
<td>Head to Head sensitivity shows how two alternatives compare to one another against the objectives in a decision.</td>
</tr>
</tbody>
</table>

Once the priority of alternative is evaluated, then it is important to analyze the impact of each criterion on alternative. Similarly, alternative strategies also need to evaluate to select customize strategy based on individual industry strength and weakness.
Figure 5.9 shows the AHP modeling analysis from above said perspective where first sensitivity analysis for comparative assessment model is explained and subsequently another AHP mode based on mitigation strategy is presented and explored with sensitivity analysis. Next subsequent Chapter discussed the analysis in detail in similar line.

5.5.1 Sensitivity Analysis for comparative assessment of Automotive Industry

As discussed in previous section 4 sensitivity procedures has been for this model. The sensitivity graph with various scenarios are shown Figure 5.10 to Figure 5.13 shows the sensitivity analysis of robust performance model of secure supply chain i.e. if the priorities of the main objectives are changed, how will the outcome be affected? Expert Choice has several very effective graphical sensitivity analyses. AHP synthesis and matrix calculations were done by the software. The detailed Sensitivity Analysis is shown in these four graphs (Figure 5.10 to 5.13) with respect to goal. The four graphic sensitivity analyses (Performance, Dynamic, Gradient, and Head to Head) shows how the alternatives' priorities change when the objectives' priorities increases or decreases.

Performance Sensitivity analysis
The Performance Sensitivity analysis is displayed in Figure 5.10 shows how the alternatives were prioritized relative to other alternatives with respect to each objective as well as overall. In this example, Organization C is approximately .16 with high RSSC performance where Information risk and security identified as major driver. Organization D is approximately 0.15 with significant contribution of procedure security and then information risk and security. Similarly, this is evaluated for each organization. Information risk and security is
identified most important criteria among all. To decide the each objective's priority (based on the decision-makers paired comparisons) uses the left y-axis. For example in this case, information is maximum importance for all organization and varied from 0.42 to 0.69. This indicates that collaborative strategies are best suited in manufacturing enterprise to minimize impact of risk & securities.

![Graph showing Dynamic Sensitivity analysis](Image)

**Figure 5.10: Performance Sensitivity Analysis**

Dynamic Sensitivity analysis

Dynamic Sensitivity analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices. If a decision-maker thinks an objective might be more or less important than originally indicated, the decision-maker can drag that objective's bar to the right or left to increase or decrease the objective’s priority and see the impact on alternatives as is shown in Figure 5.11 depicting a Dynamic Sensitivity graph.

![Graph showing Dynamic Sensitivity analysis](Image)

**Figure 5.11: Dynamic Sensitivity Analysis**
In the present dynamic sensitivity information risk and security is on higher priority with 11.2% and strengthening further can minimize the performance difference among organization. Multitier coordination risk and security followed next with 11%. Improving these two criteria’s may help organizations to maximize improvement on their RSSC performance. Again according to Dynamic Graph information Risk is needed higher consideration.

**Gradient Sensitivity Analysis**

Figure 5.12 shows Gradient Sensitivity graph the alternatives' priorities with respect to one objective at a time. In this graphs it is shown that the impact of supplier risk on all organization and identified maximum importance for organization C leading to organization A.

![Gradient Sensitivity Analysis](image)

Figure 5.12: Gradient Sensitivity Analysis

**Head to Head Sensitivity Analysis**

Figure 5.13 shows Head-to-Head graph (how two alternatives compared to one another against the objectives in a decision). One alternative is listed on the left side of the graph and the other is listed on the right. The alternative on the left is fixed while the alternative on the right can be varied, by selecting a different tab on the graph. The overall result is displayed at the bottom of the graph and shows the overall percentage by which one alternative is better than the other. It is clearly visible that the alternative information risk is most important out of all alternatives leading to Multitier coordination. The first two syntheses show the comparison and behavior of the alternatives corresponding to the goal. The last two Figures show the gradient sensitivity and node-to-node sensitivity with respect to goal.
The sensitivity analysis which is shown in the Figure 5.10 to 5.13 provides explicit detail about the decision criteria and alternative and influence over the system. The final results validated by the traditional method and given the same ranking as we get in direct evaluation but this method is more useful for any multi criteria decision making in educational institutes because of reduced bias and more generic and equal standards for each alternatives.

The AHP provides a valuable support for managers in the decision making process. It is a comprehensive framework for thinking through the decision problem. The numerical outcomes of the method are less important than the systematic thinking environment it offers. While this research presents the use of AHP in the robust performance modeling of SSC, it can also be used in evaluating alternative responses or mitigation strategies to improve performance. Mitigation strategies are the solution methodology to minimize the impact of risk and security on end to end supply chain with right focus on key issues or dimensions. In this context, next, Mitigation strategy model with sensitivity analysis is discussed and analyzed in next section.
5.6 Comparative Analysis of RSSC Mitigation Strategies

AHP model on comparative assessment of automotive industry provides ranking and key dimension important for these organization, however organization need to adopt certain strategies to improve overall RSSC performance. In this direction, various mitigation strategies are suggested based on the earlier research (Norrman and Lindroth, 2004; Mikhailov and Tsvetinov, 2004; Hendricks and Singhal, 2005; Kull and Talluri, 2008; Jyri and Vilko. 2011; Ghosh et al., 2012; Rao, 2013, Eadie et al. 2013).

AHP Model on mitigation strategies is based on fourteen dimensions (Extracted RSSC Factors, Chapter 4) and 4 RSSC business mitigation strategies for Indian automotive Industry. These four strategies are

a) Collaborative Activities (Collaboration),
b) In-House Activities,
c) Multi-functional Outsourcing, and,
d) Transportation Outsourcing,

The details of the mitigation strategies are given in Table 5.7 below:

Table 5.7: Description of Solution Strategies

<table>
<thead>
<tr>
<th>Solution Strategies</th>
<th>Description</th>
<th>Author, Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative Activities (Collaboration)</td>
<td>In Collaborative Activity partners of supply chain works in collaboration with each other. Organizations collaborate for different functions of supply chain and thus this strategy reduces the impact of risk</td>
<td>Norman and Lindroth, 2004; Eadie et al. 2013</td>
</tr>
<tr>
<td>In-House Activities</td>
<td>In house activities are those activities which are done at same organization without outsourcing any activity. In this strategy organization has their own system for almost all services</td>
<td>Hendricks and Singhal, 200; Rao, 2013</td>
</tr>
<tr>
<td>Multi-functional Outsourcing</td>
<td>Outsourcing a broader range of logistical functions is known as Multi-functional Out sourcing. On average, transportation, warehousing, or inventory management was outsourced was 96 percent, 74 percent, and 68 percent, respectively. Hence, termed the cluster &quot;multi-function outsourcers&quot;</td>
<td>Kull and Talluri, 2008; Jyri and Vilko. 2011</td>
</tr>
<tr>
<td>Transportation Outsourcing</td>
<td>Outsourcing a limited range of logistical functions, mainly transportation (plus a few packaging service), to service providers. Hence, termed these &quot;transportation outsourcing&quot;</td>
<td>Mikhailov and Tsvetinov, 2004; Eadie et al. 2013</td>
</tr>
</tbody>
</table>
The earlier researcher ((Hendricks and Singhal, 2005; Jyri and Vilko. 2011; Ghosh et al., 2012; Rao, 2013) has visualized these mitigation strategies in various forms which are further consolidated and presented here in Table 5.7. AHP process has been presented in section 5.4 and thus not repeated in this section.

These four mitigation strategies are evaluated on the basis of 14 criteria (discussed in earlier section) and formed a hierarchy structure of interdependency. Finally the aggregate score is being used to compare the different alternatives. The proposed procedure tries to reduce this uncertainty in the decisions by using the mathematical based tools like AHP, which have adequate features to reduce the error in deciding the rating. It is important to review the existing structure and the associated strengths and weaknesses of the traditional techniques. The purpose is to explore alternative methods, strategy evaluation process and increase effectiveness in the above scenario.

Figure 5.14 shows the stratified dominance structure for representing the spread of influence of RSSC evaluation. The decision hierarchy involves a goal (RSSC performance by using right mitigation strategy), 14 RSSC criteria’s and alternatives of choice (4 mitigation strategies). Pair wise judgments on the elements of the hierarchy, with respect to their parent element, to derive priorities, and then synthesize the priorities into an overall result. A hierarchical model of the problem had been developed using the AHP software Expert Choice (2000). This model is further tested by Java based AHP application developed based on the AHP concepts (refer appendix).
Figure 5.14: The Decision Hierarchy Structure for SSC Solution Strategy
5.6.1 Build a Supply Chain Risk and Security Evaluation Model for Mitigation

The assessment or evaluation of supply chain risk and security strategy process carried out to select the best mitigation strategy. In this context the valuable inputs provided may be used further for any other evaluation and development. Figure 5.15 shows the solution through pairwise comparison with respect to goal and alternative strategies.

![Figure 5.15: Solution through Pairwise Comparison of Criteria’s and Alternatives](image)

After the model is constructed, the decision-maker will compare the elements at each level of the hierarchy. In the strategy evaluation, first the criteria will be compared with respect to the objective, then the alternative with respect to the criteria. In this process it is learned about the importance of the objectives. In a sense the importance of the objectives depends on the alternatives. Next, It has been investigated the results of overall supply chain risk & security assessment in automobile manufacturing industries.

In this case, Figure 5.16 depicts that alternative collaborative Strategy is the best out of four alternatives on priority basis in ideal mode. A synthesis can be done for either the entire model or a portion of model. In Figure 5.16 notice the Ideal and Distributive mode. The Ideal mode is concerned with choosing only one alternative (the best) and the other alternatives will no longer matter. Distributive mode when all alternatives matter (Expert Choice, 2000; Rao, 2013). In this case example, the Ideal mode is selected. The Ideal mode assigns the full priority of each covering objective to the alternative that ranks highest under it. The Ideal Synthesis is appropriate if we are only interested in the single best mitigation strategy, the priorities of the other mitigation strategy will not matter much. Model consistence 0.04 is obtained within acceptance limit (Satty, 1994; Johnson, 2009).
results of the synthesis are ratio scale. The best alternative here, collaborative strategy has 41.3% priority, and the worst (In house) has 14.4%. This information is useful for prioritizing the alternatives.

![Synthesis with respect to Assess RSSC Mitigation Strategies](image)

Figure 5.16: Comparison and Synthesis with respect to Goal

Further detail sensitivity analysis is required to use right strategy in different KSSC scenarios. In next section sensitivity analysis for mitigation strategy is presented.

### 5.6.2 Sensitivity Analysis for Mitigation Strategies and Key Dimensions

Sensitivity Analysis has been carried out as per the procedure detailed in section 5.4 and 5.5. All this 4 mitigation strategies are evaluated with four different type of sensitivity analysis, resulting in 16 such scenario analysis (Figure 5.17). Figure 5.18 to 5.21 shows the inferences of some select studies out of this 16 scenario identified. All these results are documented in subsequent section. In order to avoid repetition the details of the process is not discussed again (refer section 5.5).

![Right Mitigation Strategy for Selection and Development](image)

Figure 5.17: Mitigation Strategies vs. Sensitivity Analysis

The detailed Sensitivity Analysis is shown in these four graphs (Figure 5.18, Figure 5.19, Figure 5.20, and Figure 5.21) with respect to goal. The four graphic sensitivity analyses
(Performance (Figure 5.18), Dynamic (Figure 5.19), Gradient (Figure 5.20), and Head to Head (Figure 5.21)) show how the alternatives' priorities change when the objectives' priorities increases or decreases.

Performance Sensitivity analysis

The Performance Sensitivity analysis is displayed in Figure 5.18 shows how the alternatives were prioritized relative to other alternatives with respect to each objective as well as overall. In this example, Alternative information risk is approximately .14, and Alternative theft is approximately 0.11. In this case, Collaborative strategy is approximately .41, Multi Function is approximately .26, Logistics is approximately .180, and in-house is approximately .15. Note the priorities for the alternatives sum to one. To decide the each objective's priority (based on the decision-makers paired comparisons) uses the left y-axis. For instance, information is maximum about .19. This indicates that collaborative strategies are best suited in manufacturing enterprise to minimize impact of risk & securities. Note the priorities for the alternatives sum to one. To decide the each objective's priority (based on the decision-makers paired comparisons) uses the left y-axis.

Dynamic Sensitivity analysis

Dynamic Sensitivity analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices. If a decision-maker thinks an objective might be more or less important than originally indicated, the decision-maker can drag that objective's bar to the right or left to increase or decrease the objective’s priority and see the impact on alternatives as is shown in Figure 5.19 depicting a Dynamic Sensitivity graph. In the present dynamic graph information technology showing
higher percentage (11.2%) and solution strategies like collaborative sourcing and multitier outsourcing are on higher priority with 41.3% and 26.6% respectively. Again according to Dynamic sensitivity information risk and security is needed higher consideration. Strengthening these key criteria’s can improve the performance of the organization, their ranking and minimize the difference with benchmark strategy.

Gradient Sensitivity analysis

Figure 5.20 shows Gradient Sensitivity graph the alternatives' priorities with respect to one objective at a time. To indicate where an objective's priority changes drag the red bar to either the left or right; this is shown as a blue dashed vertical line. Here, one scenario is provided with supplier risk as an criteria and identified most effective for collaborative leading to multifunction’s. Some results show that collaborative is most successful when information risk is minimum wherever multi functional strategy is more robust when demand, manufacturing and distribution risk are minimum.

Figure 5.19: Dynamic Sensitivity Analysis

Figure 5.20: Gradient Sensitivity Analysis
Head to Head Sensitivity analysis

Figure 5.21 shows Head-to-Head graph (how two alternatives compared to one another against the objectives in a decision). One alternative is listed on the left side of the graph and the other is listed on the right. The alternative on the left is fixed while the alternative on the right can be varied, by selecting a different tab on the graph. Here, one scenario is shown where multifunction strategy is compared with transportation outsourcing and shown information risk and security leading to distribution risk and security and multitier coordination are most important criteria’s. This helps in identifying key criteria to improve the key strategies, for example, catastrophic impact will be lowest while following multifunctional strategy compared to transportation strategy. Similarly, Information has more importance for multifunctional strategy.

![Figure 5.21: Head to Head Sensitivity Analysis](image)

The overall result is displayed at the bottom of the graph and shows the overall percentage by which one alternative is better than the other. It is clearly visible that the alternative collaborative is most important out of all alternatives strategies whereas information is identified as key enablers. The first two syntheses show the comparison and behavior of the alternatives corresponding to the goal. The last two figures show the gradient sensitivity and node-to-node sensitivity with respect to goal.

The AHP provides a valuable support for managers in the decision making process. It is a comprehensive framework for thinking through the decision problem. Sensitivity analysis can also help the enterprise to indicate the required shift in the enterprise focus when there are changes taking place in the environment. The key results based on detail what if analyses are highlighted along with implications for academicians and professionals. Multi criterion decision making can play a major role to strengthen the RSSC by focusing on key criterion
and alternatives. For instance, automotive industry case example, collaboration strategy is identified most appropriate for RSSC maturity.

5.7 Summary

The focus of the Chapter was limited to an identification, understanding and assessment of the critical factors, alternatives, solution strategies and decision making modeling for robust and secure supply chain. What if sensitivity analysis for RSSC will help researcher and practitioners to select and improve key factors, comparative industries evaluation on their maturity and overall development opportunity (e.g. solution strategies) of organizations.

A scheme of classifying the various sources of risk and security has been developed and evaluated. This indicates that collaborative strategies are best suited in manufacturing enterprise to minimize impact of risk & securities (e.g. business discontinuity). This has also demonstrated the use of AHP application as a useful tool for a more effective supply chain RSSC evaluation system.

Two AHP models are developed and evaluated. These models will help researcher and practitioners in details what if analysis to identify right factors and alternative solution strategy with overall development opportunity for RSSC.

The next Chapter presents a step by step process to establish the linkages of various factors using interpretive structural modeling, so derived in this study.