Mitigating Uncertainty through Purchasing Strategy
-A Case Study of an Automotive Company
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Abstract
Disaster studies have received a lot of attention recently. This paper aims to identify an optimal regional purchasing strategy in an uncertain disaster environment using automotive company as an example. This paper develops a model by Weighted Goal Programming (WGP) to analyse the required resource and the optimal resource location to mitigate the disaster damage in the supply chain. The findings evaluated by Weighted Goal Programming (WGP) are: (1) the automotive company needs to set up additional supply resource in Asian region, (2) appropriate location in Asian region has been identified for the additional supply resource; being assessed by lower logistic costs, flexible delivery and production capacity constraint, and (3) the disaster damage mitigation is also highlighted as second priority in long-term business strategies. This case study promotes more preparedness of the automotive industry for better management of unpredictable disaster in the supply chain through regional purchasing strategy. It mitigates damage and considers long-term business strategies and decisions. This friendly model can provide managing insights to other industries and supply chain in risk management.

Keywords
Disaster, Purchasing Strategy; Supply Chain Risk Management (SCRM); Weighted Goal Programming (WGP)

Introduction
An automotive supply chain is the flow of products and services from the suppliers, manufacturers, wholesalers, distributors, retailers to the final customers. The automotive industry is an inter-dependent and complicated supply chain. The players in the supply chain are closely linked together with each other in the areas of ordering, procuring, logistical handling and inventory management. Recently, in order to increase profit and to have a better cash flow, the identified automotive company has integrated all global resources and reduced supplier bases in the region. However, disruptive events from disasters and crisis have seldom been investigated. In recent year, crisis that result in supply chain disruption are prevalent. For example the Japanese earthquake in March 2011 affected global economics and environmental issues, retailers, wholesalers, manufacturers and suppliers in the supply chain suffered huge losses from the unpredictable disaster. The unprecedented difficulties also happened in Thailand due to the terrible floods in May 2012. Because of this, the automotive company needs to consider the risk due to disaster when designing the purchasing strategies in the region.

The purpose of this paper is to develop a model using Weighted Goal Programming (WGP) to analyze the required resources and the appropriate supply location for the markets in China, Japan, Taiwan, Australia, India, Vietnam, Philippines, Malaysia and South Africa. The Model considers multi-objectives with limited regional resources to mitigate the disaster damage in the supply chain.

Literature Review
Supply Chain Risk Management (SCRM)
Wee et al (2009) identified the supply chain risks in the automotive and electronic industries in Brazil and highlighted the urgency of the supply chain risk management (SCRM) and implementation. Sabio (2010) presented an efficient decomposition method in order to expedite the solution of the underlying multi-objective model by exploiting its specification. They illustrated the capabilities of the proposed model framework and solution strategy through the application to a real case study in Spain. Xia et al (2011) explored the inter-relationship between the supply chain organizational performance factors (OPF) and
the available risk operational practice (ROP), as well as the risk managerial elements in the operational process cycle (OPC) and the product life cycle (PLC). They designed a methodology for an optimal selection of risk management methods and tools based on the analytic network process (ANP) and verified this feasible strategic decision model to the suitable risk operational tactic for practitioners. Blome et al (2011) used in-depth case studies conducted among eight European enterprises and highlighted their approach to risk management and how they are related to Enterprise Risk Management.

**Risk Metrics and Performance of the Supply Chain**

Michael (2007) considered the characteristics of “accident”, “crisis”, and “disaster” as attached in table 1:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident</td>
<td>Localized events which tend to involve the failure to technology or the failure of human interaction with technology</td>
</tr>
<tr>
<td>Crisis</td>
<td>Events involving wider geographic areas and requiring quick actions by authorities and those affected by the crisis</td>
</tr>
<tr>
<td>Disaster</td>
<td>Widespread events which involve massive loss of life and significant damage to shared infrastructures</td>
</tr>
</tbody>
</table>

Spekman et al (2004) defined risk as the probability of variance in an expected outcome and it differs from uncertainty in that risk has associated with it a probability of a loss and uncertainty in an exogenous disturbance. According to Cavinato (2004), Spekman and Davis (2004), and Juttner (2005), risks in supply chain are classified into four sub-chains, the risks of the sub-chains are illustrated in table 2.

<table>
<thead>
<tr>
<th>Sub-Chains</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Delays, Unpredictable disruptions, Capacity constraints, Inflexible capacity, Production technological changes, Transportation, Excess high-value inventory, Short product life cycles to get parts, Procurement due to unanticipated demand, Poor quality for delivery</td>
</tr>
<tr>
<td>Financial</td>
<td>Supplier financial instability, Fiscal risks, untimely payments, Volatile raw material prices, Fluctuated economic, Unstable pricing, Fluctuated exchange rate</td>
</tr>
<tr>
<td>Information</td>
<td>Information security/breakdown, Forecast risks, Information system/technology outsourcing risks</td>
</tr>
<tr>
<td>Relational</td>
<td>Reputational risk due to against regulation or negative publicity, Lack of trust, Legal risks, Intellectual property rights risk</td>
</tr>
</tbody>
</table>

Performance is a key subject for enterprises; and risk is identified as priority in business operation. How to manage risk and performance in the supply chain is becoming critical. Bob Ritchie and Clare Brindley (2009) highlighted a generic model of corporate performance incorporating risk measure and performance to the three independent variables Industry Characteristics (IC), Strategic Decisions (S) and Risk (R):

\[ \text{Performance} = f(\text{IC}, S, R) \]

**Goal Programming**

Ahmed K Rifai (1996) described Goal Programming as a very powerful quantitative model for corporate strategic planning. Shih-Jieh Hung (2011) considered activity based costing (ABC) and fuzzy goal programming (FGP). The proposed model incorporates precise costing, managerial constraints, competitive advantage analysis, and risk management into divergent supply chain (DSC) forecasting and multi-objective production planning.

**Modeling**

**Methods for Case study**

Goal Programming provides two alternative ways of formulating problems with multiple goals:

1) Weighted Goal Programming (WGP) assigns weights to the goals that measure their relative importance and then seeks a solution that minimizes the weighted sum of deviations from the goals.

2) Pre-emptive Goal Programming (PGP) requires deciding on the about importance of the goals. It focuses on one goal at a time.

This model analyse the optimal purchasing strategy to mitigate the damage from unpredictable disasters in the location of the suppliers by Weighted Goal Programming (WGP).

**Model Built-up**

Step 1: Variables

Known variables:

- \( LS_i \): Logistic costs (LS) including material handling, packaging and delivery costs depending on appropriate location for the additional resource which is identified and set up
- \( PF_i \): Profit contributed by each market based on optimal additional resource assessed.
- \( RI_i \): Resource investment pondering logistic costs,
production capacity constraint and response of lead time

WRI_1: World Risk Indicators based on World Risk Indicator (WRI) of Institute for Environment Human Security of United Nation University (UNU-EHS)

$V_{T_i}$: Vendor tooling sets in region

$G(x_i)$: Goal of key performance index

$LP_i$: Minimum production volume by markets

$UP_i$: Maximum production volume by markets

$\alpha(x_i)$ Penalty Weights of key performance index over the goal

$\beta(x_i)$ Penalty Weights of key performance index under the goal

Unknown variables:

$p_i$: Number of monthly production units for markets

$AL(x_i)$: Achieved Level = $\sum x_ip_i$

$\eta(x_i)$ Deviations over Goal = $AL(x_i) - G(x_i) > 0$

$p(x_i)$ Deviations over Goal = $AL(x_i) - G(x_i) < 0$

$\sum_{i=1}^{m}V_{T_i}$: Maximum vendor tooling sets

Step 2: Minimize the weighted deviations solved by Weighted Goal Programming

$\text{Min } \sum_{i=1}^{m}(\alpha(x_i) * \eta(x_i) + \beta(x_i) * p(x_i))$

Step 3:

$AL(x_i) + \eta(x_i) - p(x_i) = G(x_i)$

$LP_i \leq P_i \leq UP_i$ Capacity constraints

$V_{T_i} \leq 1$

$\alpha(x_i)$ and $\beta(x_i)$ are the penalty weights for the goal and deviation, respectively.

WGP analysis report is summarized in table 3, we found this automotive company has to set up 2nd resource to mitigate the disaster damage considering production capacity and lead-time around Asia region except China and India. Also, the 2nd resource should be allocated in the Taiwan due to lower logistic costs and response of lead-time.

Weighted deviations show us the goal priorities of the automotive company being evaluated by deviations over/under goals; Profit and disaster damage indicator has higher deviations. Besides profit, senior management team of the automotive company have to pay more attention to disaster damage indicator due to the complicated and vulnerable automotive supply chain. The special insight is the losses incurred by the disaster higher than the investment; it is worth to build up additional resource in the Asian region.

**Conclusion and Contribution**

Based on Goal Programming and Goal Weighted assessment, the findings are (1) the automotive company needs to set up additional resource in Asian region considering disaster damage, (2) one market in Asian region has been identified for the additional resource which is assessed by considering logistic costs, flexible delivery and production capacity constraint, and (3) the disaster damage is highlighted as priority; it should be considered when senior management team make long-term business strategies.

In order to mitigate damage in the regional purchasing strategy, our study ensures more preparedness of the automotive industry to better manage unpredictable disaster in the supply chain; it demonstrates that disaster damage is one of the most important indicators in any long-term business strategies. The user friendly model can provide management insight to the other industries that wish to manage risks and reduce damage in unpredictable supply chain.

**Data Analysis**

<table>
<thead>
<tr>
<th>Goal Item $x_m$</th>
<th>Goal/Balance Level $b_m$</th>
<th>Achieved Level $f(x_m)$</th>
<th>Weighted Parameter $(\alpha_m, \beta_m)$</th>
<th>Weighted Deviations $(\eta_m, \sigma_m + \beta_m \beta_m)$</th>
<th>Production Units $P_m$</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistic Cost per year</td>
<td>$800,000</td>
<td>Average $710,288</td>
<td>5/0</td>
<td>Nil</td>
<td>Total 11,000 units</td>
<td>M1:$662,398</td>
</tr>
<tr>
<td>Profit per year</td>
<td>$80,000</td>
<td>$78,234</td>
<td>10/0</td>
<td>17,660&quot;&quot;</td>
<td>&quot;</td>
<td>Average profit</td>
</tr>
<tr>
<td>Investment</td>
<td>$35 million</td>
<td>$34.2 million</td>
<td>7/0</td>
<td>Nil</td>
<td>&quot;</td>
<td>2nd resource identified in Taiwan</td>
</tr>
</tbody>
</table>

**TABLE 3 WGP SUMMARY**
World Risk indicators | 7.21% | 7.35% | 0/10 | 884 | “ | Average WRI of 2011 and 2012

**REFERENCES**


Xia De, Chen Bo “A comprehensive decision-making model for risk management of supply chain” Expert Systems with Applications 38 (2011): 4957-4966.