Green Automotive Supply Chain for an Emerging Economy

By Gene Fisch, Jr and Tien Song Paul Neo
Thesis Advisor: Professor Charles H. Fine

Summary: This project developed requirements for a sustainable green automotive supply chain within a start-up enterprise entering the Indian emerging market. A supply chain-wide environmental management system, based on the ISO14001 standard, is used to integrate the identified green solutions for implementation and improvement within an auditable framework.

KEY INSIGHTS
1. Financial viability is an essential pre-condition for a successful green supply chain.
2. Environmental Cost Accounting, a Triple Bottom Line-based decision tool, should be used when analyzing green supply chain investments.
3. Green supply chain solutions are readily available, but require a dedicated chain-wide environmental management system to integrate, manage and implement continual improvement.

Introduction
The MIT Vehicle Design Summit (VDS) is a start-up enterprise (started from a student initiative to promote sustainable energy use) that will enter the Indian market with a new type of eco-friendly car. Recognizing the need to align its value chain's environmental impact with the product's green agenda, VDS sought to deploy a green supply chain.

Our research developed the framework for an automotive supply chain that delivers financial value and achieves environmental objectives within an emerging market. We identified the automotive supply chain functions to target for minimizing environmental impact and the corresponding green solutions for each function. Based on the ISO14001 standard, we created an Environmental Management System (EMS) Manual that forms the framework for implementation and monitoring of the proposed green solutions for the VDS supply chain. We also developed recommendations for start-up automotive companies seeking to optimize their supply chains in emerging markets.

Defining a Green Automotive Supply Chain
No standard definition exists for what constitutes a green automotive supply chain. Automotive manufacturers have sought to minimize the environmental impact of their supply chains by combining lean manufacturing with mandated supplier adoption of ISO14001-compliant EMSs. An
EMS is a strategic management framework that defines an organization’s approach to addressing the impact of its operations on the environment, while ISO14001 is the international specification for an EMS. These efforts usually constitute the extent of green supply chain management (GSCM) within the automotive industry. However, the ISO14001 standard only ensures that the EMS states clearly its scope for environmental protection and that the organization has the proper procedures in place to perform what it claims to cover in the EMS. Actual efficacy of the EMS in minimizing environmental impact is not guaranteed by the ISO14001 standard. Thus our research sought to define a green automotive supply chain from the perspective of what it would take to ensure that it actually delivers on its proposition.

Pre-conditions for Success

We have identified four pre-conditions to ensure the efficacy and sustainability of a green automotive supply chain.

Condition 1: Business Context Optimization

First, a green supply chain must be designed to fit its business context in terms of the operating environment and its organization’s status. Many are sub-optimal because they contain elements that have been taken out of context from legacy systems. A start-up enterprise like VDS has the advantage of customizing its entire supply chain for its unique business context from the outset. The primary supply chain challenges in India include the less-developed transport infrastructure, diverse quality of automotive component suppliers, high import tariffs and varied state-level corporate tax rates. These factors combine to present VDS with unique opportunities and challenges. Typically, 70% of a supply chain’s cost is fixed during the network design stage. Start-ups do not have to incur costs in re-aligning legacy supply chain networks to exploit tax breaks by locating their manufacturing facilities in business-friendly states such as Baddi or Uttarkhand. However, start-ups have limited resources that should be focused on growing the business instead of on developing stretch objectives like environmental benefits. Thus, any green solutions identified to address the contextual challenges must be readily implementable with minimal financial burden.

Condition 2: Lean Manufacturing

Second, the production system must be based on lean manufacturing principles, providing the most efficient framework for achieving clean production through continuous improvement and elimination of waste. Although lean production has been equated to GSCM by some, our research found that while it addresses many of the more tangible aspects like energy conservation and pollution reduction, it lacks the tools to enable decision-making with respect to green supply chain investments – an area our research identified as critical to its strategic success.

Condition 3: Disciplined Green Investment Decision-making

Many green investments are either initiated or deterred for the wrong reasons (like high up-front costs) because managers lack the ability to comprehensively assess their financial viability. To address the need for sound decision-making in green investments, we propose the use of accounting techniques based on a Triple Bottom Line perspective. Specifically, Environmental Cost Accounting (ECA) is identified as a necessary practice to assess the true cost of green investments, by factoring contingent costs like corporate liability, which are hidden in conventional accounting methods. Although the practice of ECA itself entails some expense, our analysis of case studies on its use by two automotive manufacturers showed that its long-term financial benefit far outweighs the short-term cost of implementation.

Condition 4: Framework for Integration and Management of Green Solutions

We found that many environmental solutions required to realize a green automotive supply chain are readily available. However, they are each specific to addressing particular activities and lack the integration required to achieve an end-to-end environmental solution for the supply chain. Our study of the EMSs used by auto manufacturers – even those pursuing GSCM – demonstrated that these were largely confined to the assembly/manufacturing function of their supply chain and were facility-specific. This stove-pipe approach opens the possibility of effort duplication and inefficiency with respect to implementation and management. However, we found no existing supply
chain-wide EMS within the automotive industry. Thus, we researched the key elements necessary to integrate the piecemeal green solutions across VDS' entire supply chain and developed an EMS structure based on a hypothetical supply chain for its India operations.

Proposed Hypothetical Supply Chain for VDS

We postulated a hypothetical supply chain for VDS based on a study of Toyota's lean production system, and General Motors' experience in establishing operations in emerging economies. From this, we identified the six functions for VDS' supply chain as: 1) Component Design, 2) Sourcing/Procurement, 3) Raw Material Transportation, 4) Assembly/Manufacturing, 5) Product Distribution and 6) Sales/Usage. For each function, we proposed if VDS should develop the capability internally or outsource to service providers based on alignment with its core business. Figure 1 shows the proposed VDS supply chain.

Green Solutions for VDS Supply Chain

To identify the relevant green solutions, we looked at the activities associated with each function in order to determine their environmental impact. For example, the key activity associated with the Sourcing / Procurement function is collaboration with Suppliers because VDS would have to decide which suppliers to use and the terms of that relationship like the extent of supplier involvement in parts design (i.e. the Component Design function mentioned above).

Lastly, we gauged the potential environmental impact based on the activities within each function. Again, for Sourcing/Procurement, the potential impact stems from the pollution generated by the suppliers' supply chains – known as indirect pollution. Figure 2 depicts the solutioning process used. With the potential environmental impacts identified, we researched the best available solutions considering their appropriability by VDS as discussed earlier.

![Figure 1: Hypothetical VDS Supply Chain](image_url)
The key green solutions are:

1) **For Sourcing/Procurement:** The US Environment Protection Agency’s (EPA) Green Suppliers Network (GSN). This initiative promotes the sharing of lean production best practices amongst supply chain partners and helps them to become green through ‘value-mapping’ techniques that also achieves financial benefits.

2) **For Raw Material Transportation and Distribution:** SmartWay Transport Partnership. Another EPA program, it promotes the use of fuel-efficient technologies, engine idling reduction and sound transport planning to achieve emissions reduction in the freight logistics industry. Though both GSN and SmartWay are US-based programs, VDS can export their lessons to its non-US operations through use of the process tools and frameworks, which it can obtain through participation in these programs at reasonable costs.

3) **For manufacturing infrastructure:** Leadership in Environmental Engineering and Design (LEED) Green Building Rating. This provides the standard to ensure that VDS’ assembly/manufacturing facilities are energy and resource efficient.

4) **For Product Recovery:** European Union End-of-Life Vehicle (ELV) Directive. Not usually considered in automotive supply chains, we nevertheless identified ELV treatment as a critical function to minimize the impact of VDS’ product at the end of their service life. The ELV directive provides guidelines for incorporating dismantling and recycling features into product design and allows the loop between sourcing and sales to be closed with eco-friendly solutions like engine remanufacturing. Figure 3 shows the proposed green supply chain solution for VDS.

**Conclusion**

Our research demonstrates that there is no single solution to realize a green automotive supply chain, but the required solutions are readily available. Preconditions like business context optimization and lean production provide the sound foundation, while tools like ECA and EMS provide good frameworks for evaluating, integrating and managing green solutions. Ultimately, however, the success of a green automotive supply chain in an emerging economy still depends on the commitment of management and staff to maintain and avoid the pitfalls of organizational fatigue – because implementing a green supply chain could well prove to be the least demanding of all of the tasks involved.
ISO14001-compliant EMS adopted to provide an auditable framework for ensuring that the green solutions for each supply chain function are properly implemented and continuously improved upon.

<table>
<thead>
<tr>
<th>VDS Supply Chain Functions</th>
<th>Impact on Environment</th>
<th>Green Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sourcing / Procurement</td>
<td>Waste and indirect pollution from suppliers’ activities and their supply chains</td>
<td>Select ISO14001-certified Tier 1 suppliers</td>
</tr>
<tr>
<td>Parts &amp; Raw Material Transportation</td>
<td>Pollution and energy wastage from transport activities</td>
<td>Encourage suppliers without an EMS to implement one</td>
</tr>
<tr>
<td>Assembly / Manufacturing</td>
<td>Direct pollution and waste from manufacturing and assembly activities</td>
<td>Become GSN Corporate Champion to suppliers to share lean production best practices</td>
</tr>
<tr>
<td>Distribution / Transportation</td>
<td>Pollution and energy wastage from inventory storage and transport to dealerships</td>
<td>Join GSN as Corporate Champion to learn lean production best practices and participate in Technical Reviews</td>
</tr>
<tr>
<td>Sales / Usage</td>
<td>Pollution and energy wastage from sales activities at dealerships</td>
<td>Employ green solutions from Parts and Raw Material Transportation</td>
</tr>
<tr>
<td>Product Recovery</td>
<td>Pollution and energy wastage from spares support activities</td>
<td>Implement lean production to continuously identify and eliminate waste in assembly/ manufacturing process</td>
</tr>
</tbody>
</table>

**Figure 3: Summary of Green Supply Chain Solution for VDS**