Windshield Wiper Supply Chain – Economic Analysis

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June 17, 2006

This is an addendum to the paper "Is lean necessarily green?"[1]. Please refer to pages 4-11 of that paper for the original data and analysis. The optimized windshield-wiper supply chain saves both CO2 emissions and fuel consumption in transportation. But it requires higher levels of inventory along the supply chain. The purpose of this addendum is to compute the net cost savings, if any, as the lean supply chain is transformed into an optimized supply chain. The available data for this supply chain is quite limited[2], which is not unusual, so we will use a few reasonable assumptions to fill in the gaps.

Fuel Savings

More efficient transportation of goods in the optimized case results in lower CO2 emissions and lower fuel consumption. We will focus here on the fuel consumption, which is more critical from an economic perspective under today's market and regulatory conditions. The fuel savings will dominate the overall cost savings.

From figures 5 and 6 in the paper:

- Total CO2 per week in the <u>lean</u> case = 27816 kg/week
- Total CO2 per week in the <u>optimized</u> case = 12912 kg/week
- CO2 savings per week (after optimization) = 14904 kg/week = 32789 lb/week

Burning one gallon of diesel releases 22.8 lb of CO2[3]. Therefore, the above CO2 savings correspond to the following fuel savings:

- Diesel savings per week = 32789/22.8 = 1438 gallons/week

Assuming an average fuel cost of $3 per gallon of diesel[4]:

- Cost savings per week = 1438 * $3 = $4314 per week
- Cost savings per year = $4314 * 52 = $224,328 per year[5]

Inventory Cost

We estimate an average final value for the materials and labor incorporated in a typical windshield-wiper arm and blade (not including the motor or other components, and without markup) at about $20[6]. The value would be lower upstream and increase as we move downstream through the supply chain (as raw materials are gradually converted into value-added finished product). Just to be conservative and to simplify the analysis, we will assume that the value is $20 per unit product throughout the supply chain. The

[1] The paper is available at http://www.suryatech.com/pages/ISSS06-IsLeanNecessarilyGreen.pdf
[2] A case study of this supply chain is available in: "Seeing the Whole", by Dan Jones and Jim Womack, published by The Lean Enterprise Institute.
[3] EPA data, from "Food, fuel and freeways" by Pirog, et al, Leopold Center, Iowa State University.
[4] Department of Energy data from http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp
[5] We have considered only the fuel cost savings and not included the value of carbon offsets.
[6] Estimated from prices quoted at www.nextag.com

supply chain delivers windshield wipers for 960 cars each week; therefore, 1920 wipers are produced and delivered each day.

In the lean case (Figure 5 in the paper), a fresh delivery is made once a day through each of the three transportation links in the supply chain. Therefore, an average of one day's worth of inventory is being processed or stored at each of the three companies in the supply chain.

- Average overall inventory level for lean supply chain = 3 * 1920 = 5760 units

In the optimized case (Figure 6 in the paper), deliveries are made once a week and there are 6 work days in a week. Therefore, an average of six days' worth of inventory is being processed or stored at each company.

- Average overall inventory level for optimized supply chain = 3 * (6 * 1920) = 34560 units of windshield wipers

Assuming that the above inventory levels cost 5% per year in interest payments or opportunity cost, and an additional 3% per year for storage in warehouses, the annualized inventory costs for the two supply chains can be estimated as:

- Lean: Average annual inventory cost = $20/unit * 5760 units * 8% = $9216 per year
- Optimized: Average annual inventory cost = $20/unit * 34560 units * 8% = $55,296 per year
- Additional inventory cost per year (after optimization) = $46,080 per year

Net Savings

The optimized supply chain saves $224,328 per year in fuel costs, but increases inventory costs by $46,080 per year. So:

- Net savings from optimized supply chain = $178,248 per year

Conclusion

In this particular supply chain example, the ratio of <increased inventory costs> to <decreased fuel costs> is about 20%. This suggests that inventory costs play only a minor role in this example, and the final outcome is dominated by fuel savings.

If we doubled the inventory cost, the net savings would decrease to $132,168 and the above ratio of costs would increase to 41%. This shows that the final outcome is still dominated by fuel savings, and the result is not highly sensitive to changes in the interest rate or any of the other cost assumptions. Moreover, if oil prices continue to increase, fuel savings would become even more dominant in the final outcome.

These results justify converting the lean supply chain in this example into an optimized supply chain that reduces fuel use and emissions. The operation would then become more profitable, while also reducing negative environmental impacts. Similar analyses can be performed for specific companies and product lines, using their data, to explore the economic and environmental advantages of applying our "emissions/energy optimization" to their supply chains.