PERFORMANCE ASSESSMENT OF SUPPLY CHAIN SIMULATIONS

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ABSTRACT

A project team at the Bogus Company is tasked to decide how full trucks should be before they are dispatched. This can be a critical decision at the suppliers, plants and warehouses, since orders are being continually filled and made available for shipment. Holding a truck until it is full could delay shipment delivery significantly, while shipping partial loads increases the freight cost per unit shipped. Earl Stanley reflects the long-standing view that the trucks should be full. Tom Gibbs wants to take a new look at the problem. His boss has been seduced by a new analytical vogue that suggests that allowing partial shipments – down to 30% of a truckload – will improve the overall supply chain 'ecology'. Joan Everly is taking a no nonsense financial look at the problem. She wants to know the bottom line effects on cash flow and profits.

1 LET THE MODEL OWNER DECIDE

Clients for supply chain models have their own rather heart-felt views as to how supply chain performance should be evaluated. The purpose of this paper is not to suggest that simulation architects should be integrating 'best practice' metrics into their tools. Rather, supply chain modeling tools should provide the model user a range of performance assessment approaches.

Different industries and enterprises within industries vary widely in the way they measure performance. Even within individual companies, the thinking may be evolving on performance measures. Everyone will agree that customer satisfaction is at the top of the performance list. But what are the measures of customer satisfaction? In some traditional consumer products industries, the percent of orders filled on time from producer to customer distribution centers was the focus. However, a high level of performance on this metric could comfortably coexist with customer dissatisfaction with other aspects of logistic policy, such as requiring full truckload orders and full pallets of individual products. Although deliveries might be on time, they may be of such large quantities as to create storage, carrying cost, and product deterioration problems at the customer distribution center and stores. A broader look at customer satisfaction would include consideration of the customer's cost of handling and storage. In fact, on-time delivery to the customer may only be a secondary concern. The consumer product retailer's primary concern is that stock be on the shelf so that the retail customer can buy it. Having it in stock at the distribution center or even in the stock room of the store is only a means to that end, and they do not guarantee availability to the customer on the shelf.

For mail order, or e-businesses, customer satisfaction with regard to delivery means keeping the company's promise. If next day delivery is promised, then the hurdle is set very high. In fact the purpose of supply chain modeling in these industries may be to determine what promise to make. The marketing department is pushing to promise rapid delivery of customer fabricated stereo systems. The manufacturing and logistics people need to assess the cost implications of final assembly at downstream locations, versus at a central facility, potentially saving several days in the delivery cycle. An effective simulation tool must be able to define performance in these terms.

Once the parameters of customer satisfaction are defined, performance assessment turns to costs. Even in an ideal world, where all cost and financial implications of supply chain performance are revealed, there is still scope for disagreement as to what should be measured. A fundamental question is whether to include the cost and financial consequences for suppliers and customers, or whether to only measure the cost effects on the client enterprise. If we are measuring profit, we must be looking at a single enterprise. But have we created profit at the expense of other participants in the supply chain? For example, has a raw materials inventory policy at a plant, designed to minimize carrying costs forced suppliers to make short production runs or stock excessive product at their site? If so, will this be of long-term benefit to the enterprise, or will pricing of raw materials eventually reflect this change, an effect that we are probably not modeling?

A total supply chain cost analysis approach would look at all cost consequences of supply chain structure and policy decisions. This approach suggests that as a team, participants in the supply chain should maximize the overall profit in the chain, rather than optimizing their own portion of it. The implication is that pricing of goods moving between participants can be adjusted to reflect a fair sharing of the profit pie. For example, a policy of shipping only full truckloads may reduce costs for a supplier, but increase costs by a greater amount to the customer. A policy that minimizes overall costs, perhaps allowing half-full truckloads under certain conditions, should allow the supplier to increase prices to cover their costs and then some, with the customer also benefiting. This scenario suggests a partnering rather than adversarial relationship between customer and supplier. Partnership is not only required for the equitable sharing of financial benefits, but also it is required in order to share the information that provides systemic performance assessment in the first place.

There are four levels of cost and financial metrics that will provide a powerful range of performance assessment to the supply chain designer:

- Cost surrogates: non-cost performance measures such as product cycle time, or total product in system are taken to vary directly with cost or are translated into cost and/or cash flow implications off line by the model client.
- Direct Costs: cost parameters including raw material costs, fixed and variable production costs, transportation costs, and storage and handling costs are accumulated in the cost of products. Final product cost is assessed as a measure of total supply chain cost.
- Enterprise cash flow: an enterprise is defined within the supply chain. Cash requirements to finance purchase of raw materials, direct costs and indirect operating costs are assessed. Payment terms by customers and to suppliers are key parameters.
- Financial performance: corporate profit and other financial metrics are used to assess alternative supply chain strategies.

Simulation models are not to be confused with the real world - they are models. Why is this observation important? Often, there seems to be a conspiracy between the simulation modeler and the technical customer to see how much detail can be captured in the model. The modeler is a virtuoso, wanting to prove his range. The customer knows a lot, and wants all of this knowledge to be captured. But the art of modeling is to disregard the irrelevant, to model just the essential factors that bear on the purpose of the model. Why include any cost modeling at all in a simulation if measurement of inventory levels or product velocity will tell the performance story. Model users may choose to do cost assessment off line. The goal of the modeler should be to have the tools available to provide the model customer the foundation for decision-making that they need and understand.

2 THE IMPORTANCE OF THE DEMAND MODEL

The power of simulation is to capture the ecological consequences of variation. Supply chains are driven by customer demand. As product is drained from the downstream end, policies and resources interact causing the movement of product through the chain. The robustness of a supply chain design is tested at moments of demand stress. What happens during periods of demand over productive capacity? What happens when forecasts miss their mark? How does the onslaught of promotional products affect the throughput of day-to-day business? Performance assessment will be a hollow exercise if demand data does not incorporate expected and unexpected changes in the weather.

3 A CASE OF POLICY ASSESSMENT

The Bogus Company has for years enforced a policy of shipping full truckloads only. One study after another conducted by Earl Stanley, supervisor of logistics at the Omaha plant, has demonstrated the efficacy of this policy. All of the other plants have followed suit. Customer complaints about shipment delays and large minimum order sizes have not been routed to Earl. They have gone to William Fitzgerald in North American marketing. William has been getting nowhere in arguing for new logistic policies because he cannot quantify the cost of customer complaints. Finally he has commissioned a study by the far-out MIT spin-off group, Meson Torque, Ltd, using a new gravitational technique to assess the truckload question. Meson's recommendation to dispatch trucks with any load of 30% or higher after waiting for one hour is controversial to say the least. The study is not supported by financial analysis but rather by a persuasive yet obscure treatise on the relation between gravitation and turbulence. Although the study has changed no minds, it has caught the attention of Barry Tiempo, head of corporate finance. Barry has decided that a supply chain simulation should be constructed to get to the bottom of the truckload question.

The modeling team consists of Joan Everly from Barry's office, Earl, Tom Gibbs from the logistics engineering group and Tony Dimts from the simulation department. The discussion centers on what aspects of supply chain performance will be impacted by truckload policy. It is agreed that shipping cost per item will benefit from full loads. It is also agreed that inventory levels at both ends of the shipment are likely to be affected, but to what degree can only be determined by the simulation. The team wants to simplify the model as much as possible, but there is concern that on-time performance may also be affected, if trucks wait too long to meet their dispatch criterion. Certain shipments may be delayed beyond their promised delivery time. Joan is interested in the bottom line. Barry has insisted that the project determine the profit and cash flow implications of the policy.

A simulation model was developed incorporating the company's principal suppliers, plants, distribution warehouses and customers. A customer demand model was developed based on historical data. The model specified demand amounts for each product at each customer site for each day over a one-year period. Cost factors for raw materials, warehousing, and freight were specified. It was decided that production run lengths would not be modified in the scenarios to be studied, so fixed and variable production costs were not included in the study.

The simulation provides parameters that dictate the capacity of vehicles both by volume and by weight, and criteria for when a vehicle can be dispatched. There are two dispatch criteria. First there is a time period during which the truck can leave only if it is full. Second there is a percent full that must be achieved for the truck to depart after the waiting period has elapsed. In all model runs, the waiting period was set to one hour. The model was run with the percent full criterion set at 10%, 30%, 50%, 70%, and 90%.

3.1 Effective Percent Full

The plot below indicates that the actual average percent full was significantly higher than the minimum criterion. This resulted from the initial one hour waiting period, during which trucks were held until full.

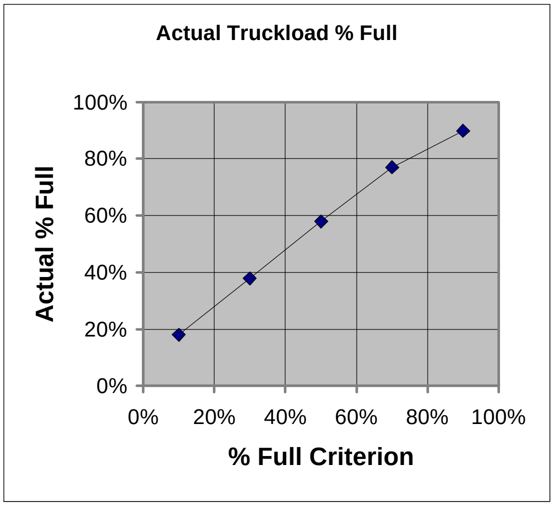

Figure 1: Actual Truckload % Full

3.2 Change in Re-ordering Policies

Reducing the criterion for truck dispatch reduced the response time to orders from the customer, and between the warehouses and the plants. More rapid response allowed a reduction in the safety stock that had to be maintained at each location in order to maintain customer satisfaction during periods of high demand. Customer satisfaction was defined as filling 99% of orders. The plot below shows the number of days of safety stock required at all locations to meet the 99% criterion.

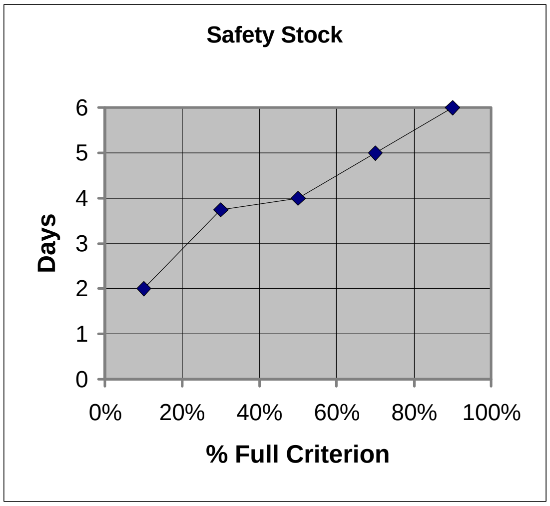

Figure 2: Safety Stock

3.3 Freight Cost

The study confirmed Earl Stanley's conviction that freight costs are materially increased when trucks dispatched with less than a full load. The plot below shows the relationship between the criteria for dispatch and total freight cost from suppliers to plants and plants to warehouses. These are the costs borne by the company.

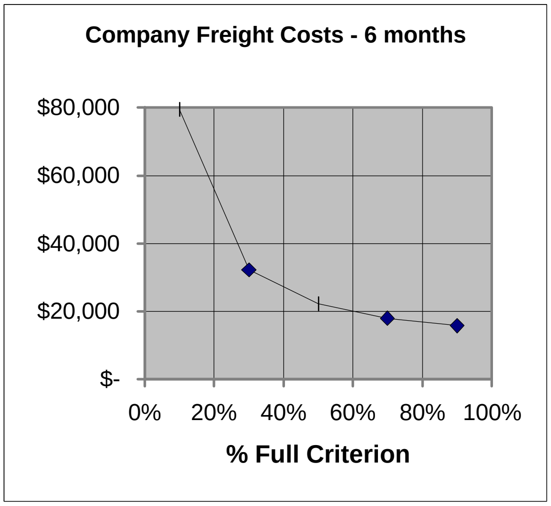

Figure 3: Company Freight Costs

3.4 Total Product In Supply Chain

Tom Gibbs was interested to see that total product in the supply chain increased with fuller trucks as shown in the plot below. This plot includes material in transit as well as material in inventory.

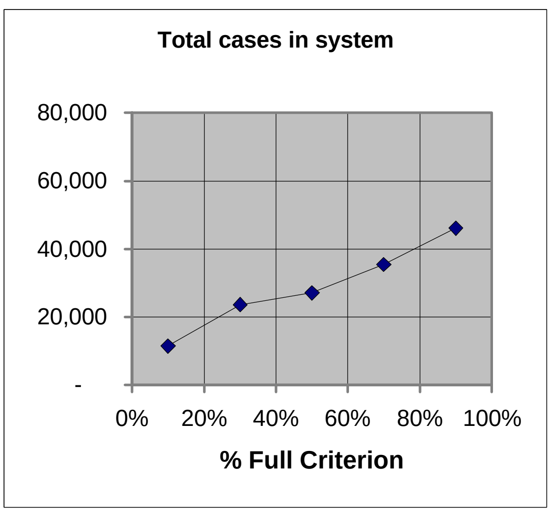

Figure 4: Total Cases in System

3.5 Cash Requirements & Inventory Value

All well and good, but Joan Everly, who has funded the study, wants to see the financial implications.

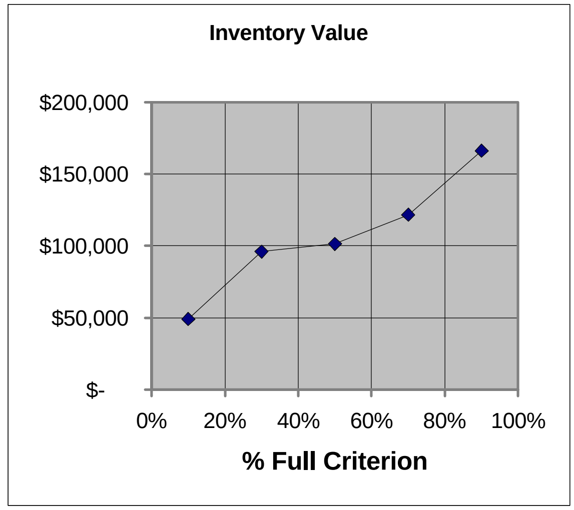

Figure 5: Inventory Value

The plot above shows the impact of the trucking criterion on company inventory value on the balance sheet. Balance sheet inventory value includes more than just the value of stock on the floor. It includes the stock in the pipeline, including sitting on trucks waiting for a full load.

Higher inventory value means one thing to Joan – more demands on cash. It's not just a question of interest, cash is a scarce resource at Bogus. More cash for inventories will mean less cash for something else. In the plot below, Joan is looking at the impact of trucking policy on Bogus' line of credit. From this point of view, the 50% solution is best since it actually puts money back in the bank.

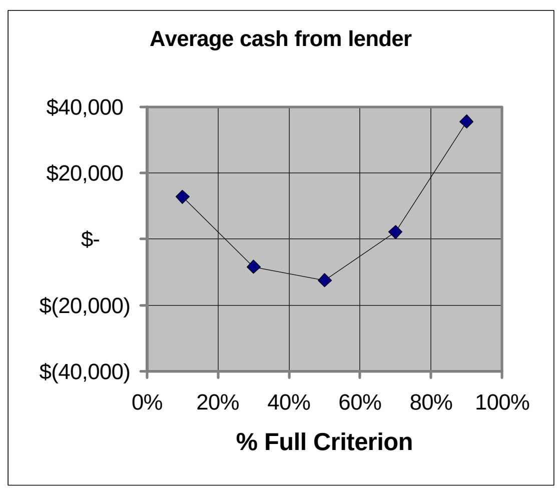

Figure 6: Average Cash From Lender

When Joan looks at the cash required at the end of the simulation period, she sees a different picture. Although the 50% criterion still produces the most cash, all criteria are producing positive cash flow (shown as negative borrowing from the bank).

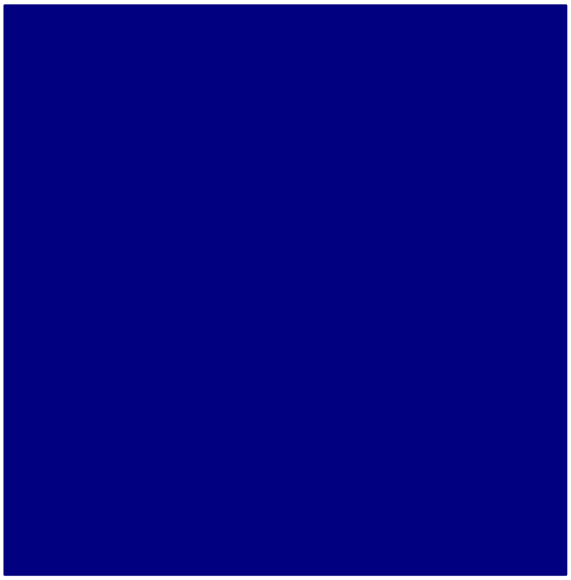

Figure 7: Cash Required at End of Run

3.6 The Bottom Line

The real bottom line for Joan Everly is profit. This computation is simplified by the elimination of indirect costs that would not be impacted by trucking practices. Joan has also kept the cost of capital out of the profit calculation. She now has to weigh between the apparent profit benefits of the full truckload (90%) criterion vs. its greater demand on capital.

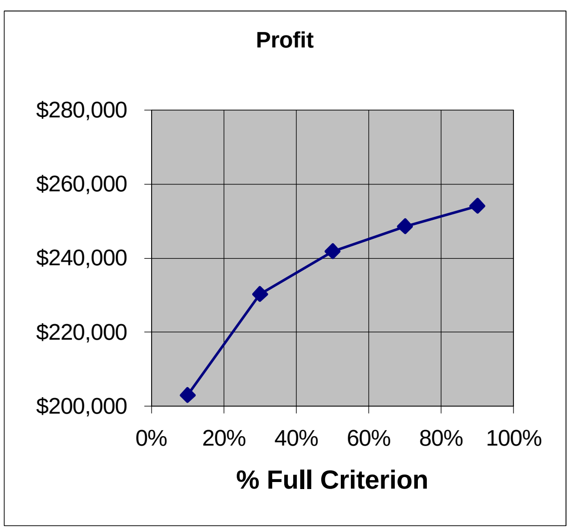

Figure 8: Average Cash From Lender

3.7 Customer Financial Impact

The team has taken into account the customer's requirement for a high percent of orders filled leaving their distribution center. They did this by adjusting re-ordering policies to achieve the targeted 99% minimum. They have not taken into account the potential decrease in inventories that the customer can carry as a result of smaller truckload deliveries. This is offset by reduced trucking expense to the customer, since they are paying the freight from the companies' warehouses.

4 CONCLUSION

Even a seemlingly simple policy decision has wide spread performance assessment ramifications. Clear and focused simulation experimentation requires a flexible and robust set of performance assessment tools. A metric, such as corporate profit, is not a single measure. It requires that a financial model be in place, running parallel to the supply chain simulation, just as the financial statements of a business model its behavior. Simple measures of quantities, rates of flow, costs and cash requirements can all play a part in assessing the consequences of strategic and policy decisions.

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DAVID J. PARSONS is a principal of Simulation Dynamics. He is responsible for development of SDI's Supply Chain Builder, a supply chain simulation and analysis tool. His experience with simulation began in 1965 with experiments in the use of natural selection algorithms to evolve architectural designs. During the 1980's he designed, built and operated several dairy-processing plants using simulation of key systems as an integral tool for design, value engineering, and trouble- shooting. Mr. Parsons received a B. A. from Harvard College and a Master of Architecture degree from the Harvard School of Design. His email and web addresses are `<Parsons@SimulationDynamics.com>` and `<www.SimulationDynamics.com>`.

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