LOGISTICS AND SUPPLY CHAIN DEVELOPMENT: PART THREE
A Quantitative Simulation of Logistics Opportunities

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This third article discusses the results of a numerical analysis that permits management to compare the logistics costs for existing inbound and outbound supply chain configurations with alternative strategies. Focus of the analysis is on direct materials and transport costs.

A quantitative simulation tool was developed from in-depth work to identify and quantify inbound and outbound logistics metrics. Effects of the material costs, safety stock requirements and transport cost were identified. The simulation tool is essentially generic and applicable to a wide range of industries.

Results obtained from this work support the validity of generic strategic guidelines for logistics and supply chain development that are core to the lean and agile paradigm. Since small and medium sized enterprises can develop in partnership on a global basis with their customers, such an analysis is of use in understanding their customer's strategic objectives.

INTRODUCTION

If a company simply does more of the same thing, costs nominally rise in a linear manner. If the company changes how it adds value ie. its operations are re-engineered, there is a change in the internal cost structure. If the company changes where it adds value it will impact on the dynamics of its relationships with suppliers and customers, and the supply chain cost structure.

Companies may decide to centralise manufacture of certain components and modules at one site, from which all other final assembly plants around the world receive goods. This allows the plant to optimise plant efficiency, leverage purchasing power to reduce unit prices from sub-contractors and optimise inbound logistics costs. To minimise stock it is necessary to produce only a single variant until late in the supply chain. This allows management to focus on volume flexibility. Transporting single variant core modules allows packaging to be optimised; deliveries can be co-ordinated based on demand and delivered just-in-time.

Despatched goods may not arrive, or arrive late at the destination due to the risks associated with transportation. To ensure operations are not interrupted, safety stocks may be kept at the destination. Equally, a just in case safety stock of similar size may be kept at suppliers for emergency despatch. Even Toyota, by the early 1970s was warehousing spare parts in North America, when they were only producing in Japan. The company typically had a six-month supply of parts at each distribution centre [1].

The size of a safety stock may be optimised using conventional economic order quantity theories. More pragmatic approaches for example include: twice the required volume per day (or more) multiplied by the number of days between transport departures, safety stock in relation to the service level policy, in relation to lead time to receive orders, or simply having a trailer load waiting on standby. Volumes despatched may be multiples or fractions of the volume per day required. This depends on the frequency of departures and the distance travelled. Various companies carry out milk runs to collect goods from suppliers within a given radius of the plant. Suppliers outside this radius, though still relatively close, may deliver direct to the point of use. Third party logistics providers may transport parts sourced from outside the trading regions.

The just-in-time concept recognises that work in progress (WIP) and finished goods (FG) stock tie up working capital non-productively [2] and [3]. The number of stock turns per year has become an important indicator of how efficient operations are. Through reduced stock, supply chains must become more responsive to market changes and recognise process changes more rapidly, hence reducing the risks and costs of obsolescence. If production processes go out of specification, low stock holding production cells have a lower risk than high stock cells of making significant quantities of stock that require rework or being scrapped.

The automotive industry has made use of transplant facilities since Ford established assembly operations in Europe. Initially these plants assembled kits imported from the United States. The assemblers started to manufacture parts in Europe either by building vertically integrated factories such as Dagenham, or developing existing engineering companies. The American big three automotive assemblers (GM, Ford and Chrysler) prefer to assemble vehicles in or near the intended market. This approach reduced the need for significant fleets of transporter ships and holding finished goods stock during transportation.

Following the end of hostilities after the pacific war, Japan initially based its industrial re-development on exports, transporting goods by sea. Since the 1980s, Japanese automotive and electronic businesses shifted the location of productive capacity by establishing transplant assembly operations in Asia, Europe and the Americas [4]. This strategy allowed the producers to avoid import quotas that would have limited their access to the markets. The West, and particularly Britain, has encouraged foreign enterprises to set up transplant assembly and component manufacturing facilities. Spin-off benefits relate to the creation of jobs in the supply and distributions sectors of the economy.

It is clear that establishing operations near to the market generally reduces the costs associated with import duties and transportation. Of significant importance to lean manufacturers is the reduction of finished goods stockholding costs. The key issue is to quantify the opportunities that can be gained from following the logistics strategy of setting up transplant assembly facilities in or close to the target market where there is a mature component supplier base. To quantify this, the authors developed a costing model focused on external logistics and transportation. A European consumer goods manufacturer used a strategy of exporting goods made in Europe to Japan. This was the basis for identifying scenarios for comparison and validating the model.

Given the emphasis businesses now place on global sourcing, what kind of competitive disadvantage do companies create for themselves by having long inbound and outbound logistics? This work aimed to provide a quantitative answer to this question. Each business has distinct types of operations, and hence the cost models used for internal operations tend to be company specific. Companies use man/hour, machine/hour, bill of material value plus percentage, and activity based costing methods to absorb overhead costs. Further analysis therefore is required to integrate overhead rates to derive comparable drivers for factory operations. These are required to determine the total business cost reductions that may be attributed to the change of factory location. Therefore, the costing model built only addressed direct costs of materials and transportation services that directly impact on the benefits of the just-in-time approaches.

DATA

Management policy may require decisions to invest capital in plant and equipment to be fact based rather than be reliant on intuition. Analysis of alternate scenarios creates data to highlight sensitivity and risk factors and determine the solution that best serves both the customer and the objectives of the enterprise. Part of project-managing improvements is to identify the ‘delta’ between the baseline scenario and other possible solutions.

Data sets were identified from a recent product providing a datum from which to assess the cost impact of alternative logistics infrastructures on a comparable product in the early stages of concurrent engineering (CE). Quantitative data were collected from product development of CE projects in other regions, third party logistics services providers, company operations, suppliers, product life cycle quantities, and so forth.

Various scenarios were modelled using Excel spreadsheets. On the full spreadsheet, space is given in the data entry sections to examine at a process level both inbound and outbound transport activities. Various modes of transport are included, ie. road and air. Durations, delays and costs for each stage of transportation are identified and the implication on stock locations identified. Assumptions were identified, ie. equal safety stock volumes are located at supplier’s despatch and customer’s goods-in. These were maintained in the logic for all scenarios modelled, and reflected current practices of the case study supply chain.

Quantitative Summary of Pipeline Stock and Transport Costs

Nominal Production Volume per day (24hrs)	5000	
Number of days producing/week	6	
OEM Internal operations Lead Time (days)	4	
Customer lead time expectations (days)	6	
Number of production days/year	288	
	Current Situation	**Scenario Possible 1**
Product Nominal cost ex-works	£80.00	£80.00
Nominal Life Cycle Volume (millions)	1.7	1.7
Mechanics Supplier	Europe	Japan
Electronics Suppliers	Japan/U.S.	Japan/U.S.
Final Assembly	UK	Tokyo
Shipping Frequency (nominal per week)	2	18
Shipping Duration (days)	3	1
Shipment Quantity	15000	1667
Dispatch Safety Stock (delivery LT x daily requirements)	15000	5000
Receiving Buffer Stock	15000	1667
Plant Line Loaded Raw Materials	5000	5000
Supply Chain End to End Transport Costs (Six days production) per unit	£0.32	£5.16
Outbound Transport Costs to market Total Value All Flow Stock (worst case £’000)	£5,214	£1,321
Total Value Safety Stock (worst case) (complete products £’000)	£9,000	£1,800
Total Stock (worst case) (£’000)	£14,214	£3,121
Stock Turns Per Year	22	108
Exposure (Min/Max %) =	7.32%	
% of Business Exposure = Transport	0.21%	46.84%
Safety Stock Volumes & Days of Supply for Variant Parts		
Number of Variants	6	46
Number of Days of Supply Acceptable	5	1
Maximum % of Sales for 1 Variant	75%	75%
Variant Creation Time (days)	2.00	2.00
Days to Supply Safety Stock (worst case)	22.50	4.50
DOS Safety Stock Recommended	3.75	0.10
DOS Safety Stock Recommended Integer	4.00	1.00

RESULTS OF THE SIMULATION

An abridged summary of results from two scenarios is presented in the Table from the Excel template produced by the authors. The two columns demonstrate comparable results obtained from ‘out of region’ manufacturing and ‘made in market’ logistics scenarios.

- Limiting liability is vital in unstable market conditions, where a product may almost immediately switch from high volume sales to being out of date stock. The ‘made in market’ solution showed that the business could reduce its liability to cover costs for materials produced by suppliers down value to 7.3% of the previous level. The scale of the reduction is also a factor of the ‘value density’ associated with the cost per item and the quantity held in the supply chain. A figure of 13.2% was calculated for a scenario that assembled variants using standard modules imported from sub-assembly plants in lower labour cost countries near the market. The ‘delta’ due to the lower labour costs was more than cancelled by the obsolescence risk due to the increased value of the materials in the pipeline. Hence, a recommendation was made that production in a country with a higher unit labour content was strategically sound due to the lower risks associated with the business case.

- Results indicate stock turns increase from the low twenties to over one hundred per year as a result of late configuration based on assembly to order in the market region, and by contracting fast response suppliers that have a significant variant flexibility.

- The ‘sourced, made and marketed in Japan’ strategy relies on just-in-time deliveries. Lead times in the datum scenario were three working weeks and reduced to four or five working days for any variant in the assemble to order in-market scenario. This is based on the assumption that both scenarios produce goods to a backlog of orders rather than make to forecast or stock.

- Various scenarios were constructed that showed total direct transport costs per unit varied between £0.06 and £5.16. The results indicate the business exposure attributed to the transport overhead rate and increased to more than 45% of the value of the goods in the pipeline. This is acceptable based on the 10:1 turn down of the pipeline stock value. The relative increase in ‘sensitivity’ of the cost of transport provides a motivation for assemblers to bring transport back under their control.

- The safety stock in these scenarios became virtually double the flow stock. Later, the lean scenario could easily reduce the safety stock buffers based on verified supply and delivery routes, producing variants based on actual sales.

- The imperative to reduce stocks of variant components caused two effects. Products made by centralised operations had far fewer variants. In the case studied, only two variants were produced. It was calculated that risk of obsolescence would drop to near zero for the ‘made in region’ scenario if 46 variants were assembled to order. Such a strategy ensures that ‘the eggs are not all in the same basket’, since safety stock for each variant is one forty sixth the plant’s daily volume capacity. It is necessary to ensure that the variant parts are produced and delivered within a very short lead time.

- The factors that most influence the value of stock in the pipeline are delivery frequency and journey duration. Given sufficient reliability in the transport system and component quality conformance, despatch and goods-in safety stocks may be reduced to a minimum. This is in effect 'lean' manufacturing.

- The 'make in market' scenario permits the company to assemble to order variants with the advantages of a shorter order fulfilment lead time and reduced pipeline stock. Effectively this is a form of 'agile' manufacturing. Once the products have become variant specific, the distribution channel is committed to this marketing mix, suggesting it is better to manufacture to order only.

CONCLUSIONS

The scenario of manufacturing products assembled in or very close to the market from a bill of materials sourced entirely from local suppliers, provides an opportunity to achieve significant impacts on the viability of the enterprise. This stems from reduced risks associated with obsolescence costs, and lower working capital is required through a more rapid 'flow' of goods. Suppliers of common specification components and product specific variant parts must be located in the same region. It is essential to avoid airfreight and long journey times for component and product transport on both inbound and outbound routes. Product final assembly and the point where variants are made should be located in the country or region of sales. Significant advances toward packaging material, recycling or reuse are also more feasible. Choice of a supplier acting as a final assembler and test plant is dependent on technological sensitivity of the product and opportunities to benchmark.

'True' just-in-time part manufacture and delivery reduces safety stock and risk, and offers the conditions for a large and profitable product mix. A requisite of the JIT system is to make variants to order and assemble against a demand backlog. Finished goods buffers are required to balance the flow in the production plant. This is achieved by agreeing maximum and minimum levels held by down stream distribution organisations. Demand for specific variants are then consolidated into small batches that increase the profit per unit.

Quantitative results based on an in-depth analysis of a European corporation, demonstrate that focusing on frequent deliveries with low pipe line stock impacts material liability, obsolescence and hence the profit of a supply chain. The generic concepts of the mass and lean production paradigms are thus validated.

The quantitative analysis described uses a generic template to calculate implications of various scenarios using direct materials and transport costs. Additional analysis is required of each company's cost absorption methods, and deltas in operating for various countries costs, to determine the total business cost savings for end-to-end supply chains.

It is imperative to have a world class supplier base close to the assembly plant and have the assembly plant located in or near the market region. Benefits stem from serving the market faster, with greater flexibility, less stock, greater stock turns, lower capital invested and hence higher return on capital employed. Designing the supply chain thus can have significant positive effects on the profitability of the enterprise. A historical example of this is the cotton weaving industry established in Northern England. Despite investment in more productive higher technology plant, once basic looms were brought to India, this spelled the beginning of the end for the Lancashire mills.

Designing products and packaging for the supply chain is an optimising process. This requires designers to innovate products that use or are based on existing parts. Core principles are commonality, compatibility, and carry-over of parts produced using current production facilities, and reuse and recycling for environmental aspects.

Too much focus on the figures themselves may detract from the key lesson that such an analysis recognises the relative position compared to competitors, and the cost savings as a percentage. Even if the figures varied by plus or minus 10, 15 or 20%, the message of our model would not substantially alter.

The volumes discussed here are minor. Manufacturing five thousand units per day is a relatively simple task in comparison with market leaders, that globally spit out fifty to one hundred million units per year. Yet the lessons to learn are equally of use to the small and medium sized enterprise as they are to the large multi-national corporations. Most of the Japanese assembly plants built in the West are near to existing suppliers, which through necessity converted from mass production suppliers to 'lean flow' partners. Manufacturing under licence, outsourcing operations, joint ventures and investing in one hundred percent owned subsidiaries are decisions required as part of a capacity expansion project.

A non-costed advantage to locating plants 'in the market' is access to technology being developed in that region. Lessons learnt then may be transferred to the company's other plants worldwide to increase corporate performance. It is important to ensure that human factors are included as a requisite to achieve the startling results discussed here.

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