Solving the Supply Chain Cost Riddle

Textbook variance analysis tools don't cut it in today's complex distribution systems. Finding something that does work is a challenge that Vancouver, B.C.-based Catalyst Paper tackled two years ago to great effect.

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Distribution costs can be more complex than many manufacturing processes, and are often a major piece of a company's overall cost structure. In spite of such significance and complexity, the accounting profession offers no proper model, approach or mathematical construct to analyze and explain the transportation component of a supply chain's cost structure.

At Catalyst Paper, a pulp and paper manufacturer based in Vancouver, B.C., this need was recognized in 2005 and several months were spent in creating an appropriate model for our $250 million annual distribution spend. The eventual model, based on SAP source data run through Access and Excel, quantified a host of variances to provide a complete explanation of distribution costs company-wide, as well as at the level of individual customer accounts. The Canadian Academic Accounting Association published these results in Accounting Perspectives in May 2007. This is a synopsis of those results.

Financial analysis of transportation cost variances versus benchmarks is usually done at a fairly high level with some specifics analyzed in detail on an ad hoc basis. The impacts of rate increases, suboptimal routings, costly carrier choices, fuel cost increases, etc., are often estimated. Though high-level generalizations and ad hoc analyses are often adequate, today's just-in-time and cost-sensitive environment justify having better tools at hand. Also, analysis at the customer account level requires very specific and precise cost and efficiency identification. The goal should be to have a tool that can handle the macroeconomic and the microeconomic variables quickly and automatically.

At Catalyst Paper, as at many other organizations, the number of customer ship-to locations and combinations of routes, modes and carriers is many times greater than the organization's number of products. And Catalyst's distribution costs are typically between 5-30 per cent of the eventual selling price not unusual for manufacturers. Catalyst has four source manufacturing plants, four means of transport to about 12 warehouses, varying handling and storage costs at each warehouse, several modes of transport and multiple carrier options for delivery to the customer. For each carrier, freight rates and surcharges vary, some billed in Canadian and some in U.S. dollars and each region and carrier have unique stow limits. Considering the company typically has 500 or more customers to serve in a single month, there are thousands of possible combinations of distribution data.

We needed a tool that could incorporate all of the key drivers of costs and sum them up simply, quantifying how each item contributed to cost overruns or under runs. The tool needed to properly identify which factors were failing to meet expected levels and which could be improved.

Various variance analysis tools could be applied here. But at Catalyst, what looked good in theory left much to be desired when applied to real cost data for complex distribution systems. Textbook examples of widget manufacturing costs didn't have the complexity of interdependent variables that supply chains typically exhibit; and real-life data is fraught with errors and adjustments that must be dealt with to provide a complete explanation of distribution variances.

Issues of data integrity and completeness can be daunting. Seemingly insignificant flaws in source data can destroy the integrity of entire analyses if not treated properly. Filtering, applying certain rules to certain types of errors, dealing with prior period accounting entries and such can wreak havoc with the eventual reports. Don't underestimate the importance of getting the data complete, consistent and correct; it needs to fit neatly into a somewhat unforgiving model.

This article provides an outline of the concepts and output that

Exhibit 1 – Transportation Cost Variance, July 2007 vs Plan (Favourable/(Unfavourable)
Actual and Plan Data Records

						Plants, Units		1st Leg Transp $/Unit				
Customer	Whse	Mode	Carrier	Loads	Units	1st Plant	2nd Plant	1st Plant	2nd Plant	Whse to Customer, $/Unit	TOTAL $/Unit	TOTAL, $
ACTUAL DATA												
ABCInc	Whse1	TRUCK	ABC Truck	25	500	500	-	15	17	80	95	
ABCInc	Whse2	RAIL	DEF Rail	5	360	360	-	20	25	60	80	
ABCInc	Whse2	TRUCK	Joe's Truck	70	1,400	1,400	-	20	25	70	90	
ABCInc	Whse2	TRUCK	XY2 Trucking	30	600	600	-	20	25	65	85	
ABCInc	Whse2	TRUCK	Bill's Trucking	4	100	100	-	20	25	75	95	
K&V Ltd	Whse3	Rail	GH Rail	5	400	300	100	30	35	60	91	
					3,360	3,260	100	20	25	68	$89.08 /unit	$299,300
PLAN DATA												
ABCInc	Whse1	TRUCK	ABC Truck	40	800	800	-	15	17	80	95	
ABCInc	Whse2	RAIL	DEF Rail	1	85	85	-	20	25	50	70	
ABCInc	Whse2	TRUCK	Joe's Truck	100	2,000	2,000	-	20	25	70	90	
K&V Ltd	Whse3	Rail	GH Rail	10	800	400	400	30	35	60	93	
					3,685	3,285	400	21	25	70	$91.17 /unit	$335,950
Total Variance, all customers. Note: negative number means more money was spent on freight than planned.											Difference	$36,650

Catalyst settled on. Each situation won't be the same, but the general concepts are portable.

At the highest level, total distribution costs will be more or less than budgeted. Observe Exhibit 1. The company spent $36,650 less than budget. Try to identify the reasons for those savings; one can discern soon enough that transportation costs were low due to reduced sales volume. Now try to identify the reasons that costs were $2.09 per unit less than the budget of $91.17. The reasons for that difference aren't obvious but the major factors can be identified fairly quickly. Imagine having to do this for hundreds or thousands of customers. The challenge is to break down the total variance into numbers that identify all the reasons that costs aren't as planned whether at a corporate level or by customer.

In the example, you'll notice cost impacts, including:

- 3,360 units were sold in the period versus a plan to sell 3,685;
- the proportion of sales to each customer was not as planned;
- XYZ Trucking hadn't been considered in the budget but took 30 truckloads to ABC Inc.

There are many other reasons for costs to vary from the plan shown. The trick is to quantify each of them appropriately in a solution that adds to $36,650. The following categories of variances are used to arrive at the solution: volume, customer mix, distribution mix and carrier charges.

Volume variance

The volume variance calculates the overall impact of selling more or less than budgeted. Even if all cost factors are on plan and the customer mix is as planned, a change in volume will change total distribution costs. The calculation of the impact of volume changes is straightforward: the overall difference between actual and budgeted volume times the total budgeted cost per tonne. Exhibit 2 shows the calculation of a $29,629 favourable volume variance for our example. Distribution costs are lower than planned, partly because the company sold less than planned.

Once the volume impact is explained, the remaining variance calculations explain why the per unit costs are higher or lower than planned. In our example, the planned distribution costs were $91.17 per unit while the actual costs were $89.08 per unit. The main.09/unit explanation involves customer mix, distribution mix and carrier charges. The customer mix and distribution mix variances identify changes in the proportions of customers, routes, modes etc. that affect overall costs.

Customer-destination mix variance

The customer or destination mix variance determines the

Exhibit 2 – Transportation Cost Variance, July 2007 vs Plan (Favourable/(Unfavourable)
Calculation of Variances

						Mix Variances						Price and Efficiency Variances			
Customer	Whse	Mode	Carrier	Loads	Units	First Leg	Last Leg	Routing	Mode	Carrier	Total Mix	Rate	Yield	Price/Effic	Total
ABC Inc	Whse1	TRUCK	ABC Truck	25	500	4,812	25,664	30,476	-	-	30,476	-	-	-	30,476
ABC Inc	Whse2	RAIL	DEF Rail	5	360	(5,456)	(18,873)	(24,329)	(12,986)	-	(37,314)	(350)	(3,250)	(3,600)	(40,914)
ABC Inc	Whse2	TRUCK	Joe's Truck	70	1,400	13,040	45,108	58,148	67,180	49,000	174,328	-	-	-	174,328
ABC Inc	Whse2	TRUCK	XYZ Trucking	30	600	(12,000)	(41,511)	(53,511)	(42,000)	(39,000)	(134,511)	-	-	-	(134,511)
ABC Inc	Whse2	TRUCK	Bill's Trucking	4	100	(2,000)	(6,918)	(8,918)	(7,000)	(7,500)	(23,418)	-	0	-	(23,418)
K&V Ltd	Whse3	Rail	GH Rail	5	400	500	-	500	-	-	500	-	-	-	500
						$ 3,360	$ (1,104)	$ 2,366	$ 5,194	$ 2,500	$ 10,060	$ (350)	$ (3,250)	$ (3,600)	$ 6,460

Volume Variance

Actual Units	Plan Units	Plan	$/Unit	Volume Variance	
3,360	3,685		$ 91.17	29,629	favourable

Destination Mix

	Actual Units	Plan Units	Plan$/Unit	Dest'n Mix	
ABC Inc	2,960	2,885	90.80	(29,913)	
K&V Ltd	400	800	92.50	30,474	
	3,360	3,685		561	favourable

	Units	x $/Unit	$
Actual	3,360	89.08	299,300
Plan		$ 91.17	$ 306,321
Mix			$ 10,060
Price			$ (3,600)
Destination			$ 561
Total Cost/Unit Variance			$ 7,021
Volume Variance			$ 29,629
Total Cost Variance			$ 36,650

Variances		Cost/Unit
Budgeted cost, $/unit		$ 91.17
FIRST LEG	$ 1,104	$ 0.33
LAST LEG	$ (3,470)	$ (1.03)
MODE	$ (5,194)	$ (1.55)
CARRIER	$ (2,500)	$ (0.74)
RATE	$ 350	$ 0.10
YIELD	$ 3,250	$ 0.97
Destination	$ (561)	$ (0.17)
Actual Cost, $/Unit		$ 89.08

impact of shipping to different customers. Rarely does a company manage to ship to all of the customers they planned to and in precisely planned proportions. A calculation of the mix impact must be done for each customer. Some will be favourable (i.e. more product shipped to low-cost locations) and some will be unfavourable, and the results are summed up to arrive at the total cost variance attributable to customer mix. The customer mix variance multiplies the planned cost per unit for each destination by the difference between the actual volume shipped and the volume that would have been shipped if this customer received the planned proportion of total sales.

In Exhibit 2, the destination mix calculation shows that the company sold more product to ABC Inc. than planned and less to K&V; and, because K&V was a more expensive ship-to location than ABC, the net result was favourable, a savings of $561.

While the first two variances are fairly simple to calculate and represent high-level impacts, the remaining variances are more complex and involve calculations at the level of groupings of actual deliveries.

Distribution mix variances

Distribution mix variances deal with the logistical complexities involved in routing product from source to customer. The selection from many options may seem simple enough to deal with in day-to-day operations, but these combinations complicate the mathematical analysis of costs. Supply chains typically involve choices that depend on other choices, which is why the mathematics for supply chain cost variance analysis can be much more complex than manufacturing cost variance analysis. For example, the choice of one manufacturing plant over another can result in a different set of warehouse options; the warehouse chosen to route the product through may have different outbound mode options than another warehouse, and so on. We won't go into the specific explanations and proofs of the mathematics in this brief article, but suffice to say that the combinations of routes and modes and carriers complicate the variance analysis math at each turn.

Catalyst breaks its distribution mix variances into the following:

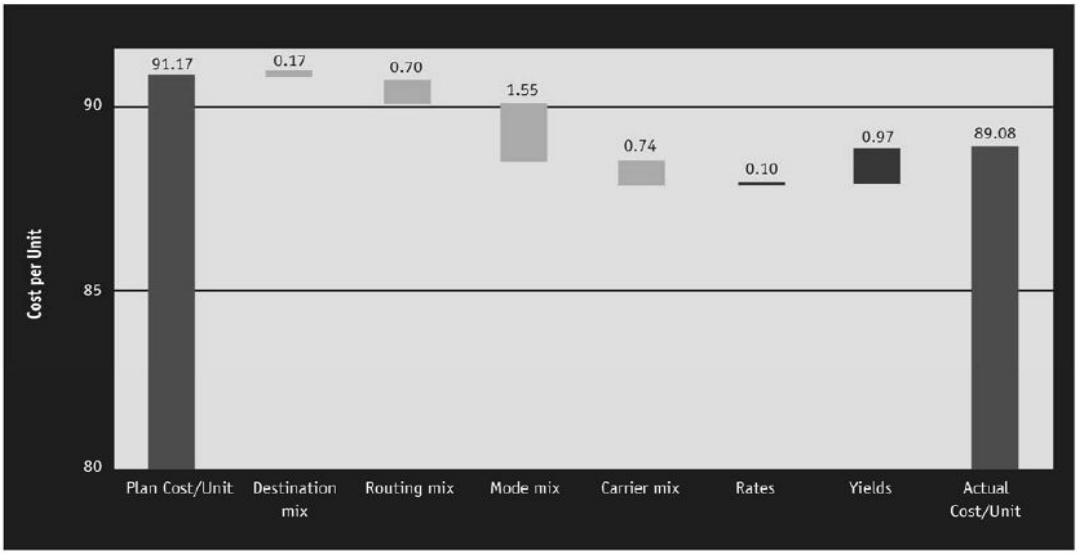
- First-leg route (or source plant)
- Last-leg route (or warehouse)
- Mode
- Carrier

The first-leg route variance and the last-leg route variance quantify the impact of the end-to-end routing decision. If product can be sourced from plants at different geographic locations and shipped to one or more warehouses, the choices made can result in significantly different costs. Capacity constraints, production problems, strikes, weather, and a host of other factors can result in sourcing and routing product through suboptimal channels. Isolating the impact of routing decisions can go far to optimizing a supply chain or identifying bottlenecks and shortcomings.

Mathematically, the calculations of the route variances are relatively complex, requiring a specific data record structure and formulae to avoid double-counting and overlap with other variance amounts. Accountants will recognize the general idea of mix variances from their management accountant training, but will find that the routing mix variance calculations here go beyond textbook examples because of the interdependency of the first-leg mix and last-leg mix.

In Exhibit 2, the example points to effective routing saving the company $0.70 per unit; a loss of $0.33 on the first leg and a

Exhibit 3 – Transportation Costs per Unit Versus Budget



saving of $1.03 on the final leg to the customer by routing a higher proportion of product through Warehouse 2, which has lower planned last-leg costs to ABC Inc. than Warehouse 1.

The mode mix variance recognizes the impact on costs of selecting various modes of transport between which there can be large differences in cost. Customer preference, late production, late orders or adverse weather conditions are examples of what can create deviations from a planned mode mix and can be the primary determinant of average freight cost.

The mode mix variance reflects whether the actual mode mix (at benchmark costs) was more/less expensive than the benchmark mode mix. The mode mix variance calculates the impact of shipping via a different mix of modes than planned and can point out the impact of bottlenecks or equipment shortages.

In the example, we find that the company managed to save $1.55 per unit in distribution costs due to an effective mode mix. The company shipped a higher proportion of product by rail than planned. Rail had a planned cost per unit to ABC that was less than the average cost per unit for trucking. The carrier mix can be influenced by carriers' relative rates, equipment shortages, strikes, core carrier programs, contractual agreements on minimum or maximum volumes, etc. There can be a very significant variation in rates from one carrier to the next and some carriers may even have differing vehicle capacities that can influence average yield. The carrier mix variance reflects whether the actual carrier mix for a given mode was more or less expensive than the benchmark or budgeted carrier mix.

In our example, a judicious selection of carriers resulted in a savings on overall freight costs of $0.74 per unit.

Carrier charge variances

Once the route, mode and carrier have been selected and costed, the analyst needs to determine the impact of the rates charged and the efficiencies achieved. Mathematically and intuitively, these price and efficiency variances are easier to determine than the distribution mix variances, but they still require attention to detail. Catalyst breaks their carrier charge variances into two types: rates and efficiency.

Rate variances include, for instance, the difference between the actual and planned freight rate, fuel surcharges, border charges, brokerage fees, port charges, etc. Essentially, each component of the actual cost (in dollars per load or dollars per unit) is compared to the budget and the difference in cost is applied to the actual volume shipped to arrive at the dollar impact. In Catalyst's case, transportation is transacted in multiple currencies, so the exchange has to be isolated from other factors.

In the example, rates charged by DEF Rail were slightly higher than planned, adding $0.10 per unit to average freight costs.

Efficiency, in Catalyst's case, is limited to the difference between the actual and planned yields (volume per truckload, rail car or container). The difference determines, for instance, the number of extra truckloads or carloads that were required due to low yields (which may have been the result of poorly planned stows or suboptimal order sizes). The change in the number of trips is applied to the planned cost per trip to determine the dollar impact of the efficiency loss or gain.

In this example, the plan was to ship 85 units per rail car but only managed 72, adding $3,250 or $0.97 per unit to distribution costs.

Reporting the results

The rubber hits the road in any cost analysis when the results are presented. The variances need to be summarized in a clear and productive format. The method of reporting and explaining variances will determine if the results are used for effective change. Consider using one or more of the following presentation methods:

- Summarize the results graphically, as shown in Exhibit 3, for the overall results or for individual customers. This can be particularly powerful for explaining overall freight costs.
- For each customer or for major customers, present a single page of actual and benchmark summary records with a listing of the variances. Sales reps can find this particularly useful for assessing customer profitability;
- Top-ten lists for each type of variance, showing the ship-to destinations with the highest impact. For example:
  - carriers or warehouses providing the worst/best yields;
  - warehouses arranging the worst/best carrier mix;
  - warehouses experiencing the worst/best mode mix; and
  - customers whose freight costs are most sensitive to exchange fluctuations.

These reports can identify business process and/or logistical issues that create increasing costs or keep your company from achieving planned efficiencies.

As the relevance of distribution to industry grows, it's increasingly important to have immediate and complete analysis tools for those costs. While all of the attributes of transportation costs and their efficiencies aren't covered, a general approach has been illustrated that can possibly be applied to each specific circumstance.

For a more complete examination of the formulae and suggested record structure, see A Case Study of a Variance Analysis Framework for Managing Distribution Costs, Accounting Perspectives, 2007, Volume 6. Number 2, Canadian Academic Accounting Association.

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