Solving the Supply Chain Cost Riddle

Developing good analysis tools will help zero in on distribution costs that could erode planned efficiencies or savings at your company.

By Kevin Gaffney and Valeri Gladkikh

Distribution costs, like distribution activities, can be more complex than those of 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 little guidance in terms of a proper model, approach and mathematical construct to analyze and explain the transportation component of a supply chain's cost structure.

At Vancouver, BC-based Catalyst Paper, we recognized such a need in 2005 and spent several months formulating, developing, fine-tuning and documenting 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" (differences between actual and budgeted costs and efficiencies) to provide a complete explanation of distribution costs at the company-wide level as well as at the level of individual customer accounts. The Canadian Academic Accounting Association peer reviewed those results and published them in their academic journal, *Accounting Perspectives,* in May of this year. What follows is a less-academic, less-mathematical synopsis of those results.

In our experience and from our research, financial analysis of transportation cost variances versus benchmarks (either a budget or a prior period) is usually done at a fairly high level with some specifics analyzed in detail on an ad hoc basis. The high-level impacts of rate increases, sub-optimal routings or modes, poor load yields, costly carrier choices, fuel cost increases, weather and strikes are often estimated or generalized. Though high-level generalizations and ad hoc analyses are often adequate, today's just-in-time and cost-sensitive environment justify having much better tools at hand. As well, 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 through logic, math and programming.

At Catalyst Paper, as at many other organizations, the number of customer ship-to locations and combinations of routes, modes and carriers available to service those locations is many times greater than the organization's number of products and variants of those products. As well, Catalyst's costs of distributing product to customers typically range between 5% and 30% of the eventual selling price, which is not unusual for manufacturers.

Catalyst has four source manufacturing plants, one to four means of transport to about a dozen warehouses, varying handling and storage costs at each warehouse, several modes of transport and multiple carrier options for the eventual delivery to the customer. For each carrier, there are varying freight rates and surcharges, some billed in Canadian dollars and some in US dollars and each region and carrier can have unique stow limits. Taking into account the fact that the company typically has 500 or more customers to service in a single month, there are thousands of possible combinations of plant, warehouse, mode, carrier, and currency. As such, it was deemed important for the company to determine the full math and logic for an automated variance analysis tool that could break down and quantify fully the differences between actual and budgeted costs. We felt that we needed a tool that could incorporate all of the key drivers of costs, such as the destination mix, source plants, warehouses and cross-dock locations, modes of transport, carriers, freight rates, surcharges, exchange rates, yields, and a host of other costs and could bring them to an intelligible and intuitive summary, quantifying how each of these items contributed to cost overruns or underruns against a budget, against an ideal, or against a prior period. The tool needed to properly identify which factors in the supply chain were failing to be at expected levels and which had opportunities for improvement.

Accountants will recognize at this point the applicability of the variance analysis tools they learned as students. At Catalyst, we started with that model, but found in short order that what looked good in theory in textbook analyses of manufacturing costs 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 unfortunately fraught with incompleteness, errors, adjustments and corrections that need to be handled properly in order to provide a complete answer to the questions about why reported costs are not as planned.

While we will not discuss data compilation and data cleansing in any detail, we would be remiss to not mention that the issues around data integrity and completeness can be daunting. Seemingly insignificant flaws in the source data can destroy the integrity of the entire analysis 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 math and with the eventual reports. Do not underestimate the importance of getting the data complete, consistent and correct, as it needs to fit neatly into a somewhat unforgiving mathematical model.

Without delving into details of the myriad of complexities inherent in logistics, systems and data, the following provides an outline of the concepts and output that Catalyst settled on. Your particular situation will not be the same as that of Catalyst, but the general concepts are generally portable.

At the highest level, distribution costs in total will be more than or less than budgeted. Take a look at the example in **Exhibit 1**. You can readily see that the company spent $36,650 less than budget. Scan through the numbers and try to identify the reasons for those savings. In this simple example, one can discern soon enough that transportation costs were lower than plan as a result of reduced sales volume; only 3,360 units were sold versus a plan of 3,685. 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 are not readily apparent, but the major factors can be identified with a few minutes of eyeballing the data. Now imagine having to do this for dozens or hundreds or thousands of customers. The task at hand is to break down the total variance into a set of numbers that identify all of the reasons that costs aren't as planned—whether at a corporate level or by customer.

Scanning through the numbers in the example, you'll notice cost impacts, including, for example:

- 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.;
- DEF Rail's rates were higher than planned;
- DEF Rail was budgeted to carry 85 units per railcar but only took 72 (360 units in 5 railcars).

TRANSPORTATION COST VARIANCE ANALYSIS July 2006 vs Plan [Favourable/(Unfavourable)]

ACTUAL AND PLAN DATA RECORDS						Plants, Units		1st Leg Transp $/Unit				
Customer	Wrhse	Mode	Carrier	Loads	Units	1st Plant	2nd Plant	1st Plant	2nd Plant	Whse to Customer, $/Unit	TOTAL $/Unit	TOTAL, $
ACTUAL DATA												
ABC Inc	Whse1	TRUCK	ABC Truck	25.0	500	500	—	15.00	17.00	80.00	$95.00	
ABC Inc	Whse2	RAIL	DEF Rail	5.0	360	360	—	20.00	25.00	60.00	$80.00	
ABC Inc	Whse2	TRUCK	Joe's Truck	70.0	1,400	1,400	—	20.00	25.00	70.00	$90.00	
ABC Inc	Whse2	TRUCK	XYZ Trucking	30.0	600	600	—	20.00	25.00	65.00	$85.00	
ABC Inc	Whse2	TRUCK	Bill's Trucking	4.0	100	100	—	20.00	25.00	75.00	$95.00	
K&V Ltd	Whse3	Rail	GH Rail	5.0	400	300	100	30.00	35.00	60.00	$91.25	
					3,360	**3,260**	**100**	**20.45**		**68.48**	**$89.08/unit**	**$299,300**
PLAN DATA												
ABC Inc	Whse1	TRUCK	ABC Truck	40.0	800	800	—	15.00	17.00	80.00	$95.00	
ABC Inc	Whse2	RAIL	DEF Rail	1.0	85	85	—	20.00	25.00	50.00	$70.00	
ABC Inc	Whse2	TRUCK	Joe's Truck	100.0	2,000	2,000	—	20.00	25.00	70.00	$90.00	
K&V Ltd	Whse3	Rail	GH Rail	10.0	800	400	400	30.00	35.00	60.00	$92.50	
					3,685	**3,285**	**400**	**21.09**		**69.54**	**$91.17/unit**	**$335,950**
Total Variance, all customers... Note: negative number means that more money was spent on freight than planned.											**Difference**	**$36,650**

Exhibit 1.

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

VOLUME VARIANCE

Simply put, 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 precisely as planned, a change in volume will change total distribution costs. The calculation of the impact of volume changes is simple and straightforward: the overall difference between actual and budgeted volume times the total budgeted cost per tonne. **Exhibit 3** shows the calculation of a $29,629 favorable volume variance for our example. Distribution costs are lower than planned, partly because the company sold less than planned.

Once the volume impact has been explained, the remaining variance calculations deal with explaining 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 $2.09/unit explanation will involve customer mix, distribution mix and carrier charges.

The customer mix and distribution mix variances identify changes in the proportions of customers, routes, modes and such that impact overall costs. **Exhibit 2** illustrates these choices and how they can create complexity in supply chain cost analysis.

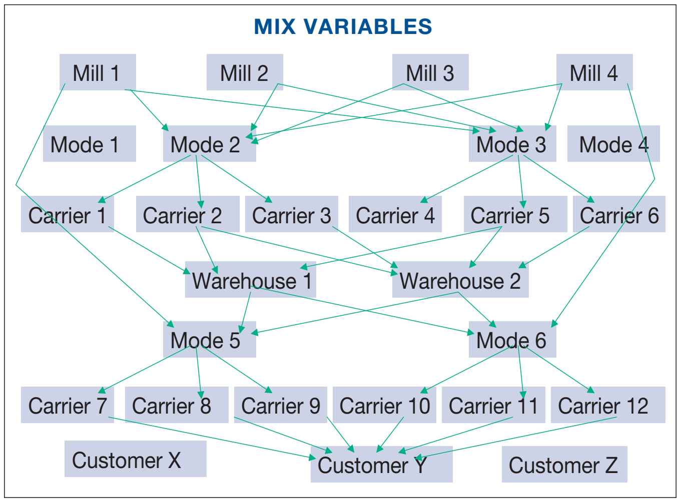

Exhibit 2.

CUSTOMER MIX VARIANCE

The customer mix, or destination mix, variance determines the impact of shipping to different customers. For those customers who don't ship directly to their customers' homes or places of business, the equivalent could be shipping to their retail outlets or distribution centers, but the general concept is the same. Rarely does a company manage to ship to all of the customers they planned to and in exactly those planned proportions. A calculation of the mix impact is done for each customer, some will be favorable (i.e. more product shipped to low-cost locations) and some will be unfavorable, and the results are summed 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

TRANSPORTATION COST VARIANCE ANALYSIS

July 2006 vs Plan [Favourable/(Unfavourable)]

CALCULATION OF VARIANCES

						Mix Variances						Price and Efficiency Variances			
Customer	**Wrhse**	**Mode**	**Carrier**	**Loads**	**Units**	**First Leg**	**Last Leg**	**Routing**	**Mode**	**Carrier**	**Total Mix**	**Rate**	**Yield**	**Price/Effic**	**Total**
ABC Inc	Whse1	TRUCK	ABC Truck	25.0	500	4,812	25,664	30,476	—	—	**30,476**	—	—	—	**30,476**
ABC Inc	Whse2	RAIL	DEF Rail	5.0	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	70.0	1,400	13,040	45,108	58,148	67,180	49,000	**174,328**	—	—	—	**174,328**
ABC Inc	Whse2	TRUCK	Small Trucking	30.0	600	(12,000)	(41,511)	(53,511)	(42,000)	(39,000)	**(134,511)**	—	—	—	**(134,511)**
ABC Inc	Whse2	TRUCK	Bill's Trucking	4.0	100	(2,000)	(6,918)	(8,918)	(7,000)	(7,500)	**(23,418)**	—	0	—	**(23,418)**
K&V Ltd	Whse3	Rail	GH Rail	5.0	400	500	—	500	—	—	**500**	—	—	—	**500**
					3,360	**(1,104)**	**3,470**	**2,366**	**5,194**	**2,500**	**$10,060**	**$(350)**	**$(3,250)**	**$(3,600)**	**$6,460**

Volume Variances				
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**
Variances	**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**

Exhibit 3.

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 3**, the destination mix calculation shows that the company sold more product to ABC than planned and less to K&V; and, because K&V was a more expensive ship-to location than ABC, the net result was favorable, 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 of individual manufacturing plants, warehouses, modes, and carriers 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 their 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.

In **Exhibit 3**, the example points to effective routing saving the company $0.70 per unit; a loss of $0.33 on the first leg and a 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 (for instance, rail, truck, intermodal, container or break-bulk) 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 an $80 planned cost per unit to ABC that was less than the average $90 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 and a host of other factors. 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/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 and to grasp than the distribution mix variances, but they nonetheless require much attention to detail when dealing with real-life data from today's complex computer systems. 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, accessorials, border charges, brokerage fees, port charges, etc. Essentially, each component of the actual cost (in dollars per load or dollars per unit as the case may be) 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 impact has to be isolated from the 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, railcar 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 our example, we planned on shipping 85 units per railcar 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 finally presented. The variances need to be summarized in a format that can be understood and, of course, acted upon. The method of reporting and explaining variances will determine whether the results are treated as "nice to know" or actionable. You may want to consider utilizing one or more of the following methods of presentation:

- Summarize the results graphically, as shown in **Exhibit 4** for the overall results or for individual customers. This can be particularly powerful for explaining the overall freight cost results for a period.
- For each customer or for major customers, a single page of actual and benchmark summary records with a listing of the variances, highlighting those variances with the highest absolute values. 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;

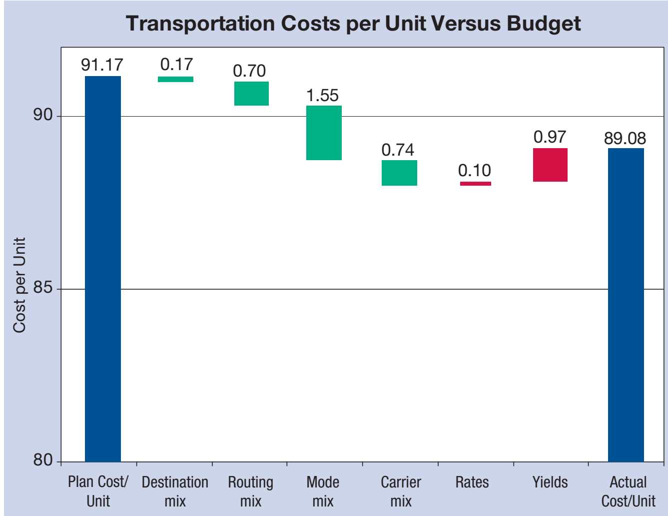

Exhibit 4.

  - — warehouses experiencing the worst/best mode mix;
  - — carriers whose rates have increased significantly beyond budget or more than their competitors;
  - — customers who have been added to or dropped from the sales mix with large impacts on average cost;
  - — modes or carriers most impacted by increasing fuel surcharges;
  - — customers whose freight costs are most sensitive to exchange fluctuations.

These report examples can provide immediate results in terms of identifying business process and/or logistical issues that are resulting in increasing costs or are keeping your company from achieving planned efficiencies or cost levels.

As the relevance of distribution to industry grows with each passing year and each increase in fuel prices, it becomes increasingly important to have immediate and complete analysis tools for those costs. While we readily acknowledge that we have not covered all of the attributes of transportation costs and their efficiencies and that our own experience is not directly applicable to most other organizations' circumstances, we hope that we have illustrated a general approach that you can apply to your specific circumstances.

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. ■

Kevin Gaffney is senior business analyst, and Valeri Gladkikh is a financial analyst at Catalyst Paper Corporation. The authors can be contacted by email at: Kevin.Gaffney@catalystpaper.com or valeri.gladkikh@telus.net.