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Analysis of distribution costs at Fissler Holz Gruppe GmbH

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INTRODUCTION

Jasmine Frey is the new business analyst at Fissler Holz Gruppe GmbH (FHG) in the Black Forrest in Germany. She is charged with the task of developing and implementing a new way for FHG to better understand and manage its distribution costs.

FHG is a traditional, family-owned lumber company that produces and sells sawn wood products that are used in construction, such as floorboards, beams, and plywood. Lumber has always been used for traditional house construction in many parts of Germany and neighboring countries such as Switzerland, Austria, and France. In recent years, more lumber is used in combination with modern construction methods for family homes and for much larger buildings, such as office buildings, manufacturing plants, exhibition and convention centers, and university lecture halls. The company has steadily grown with the rise of lumber construction.

FHG comprises the head office and two production plants in the Black Forrest region and four warehouses in the south, north, center, and eastern parts of Germany, from which dozens of customer locations are being served. FHG has outsourced most of its distribution activities and works with several carrier companies to transport products from the plants to the warehouses and from the warehouses to the customer locations, either by truck, rail, or barge. Both plants can produce almost all products, and the warehouses can store basically the entire product range. There is considerable flexibility regarding the transportation modes that can be used, but not all locations are connected by rail or barge.

Although distribution costs were a significant part of total costs, FHG had very little insights into these costs. It planned distribution activities on a daily basis: shipments of particular products from specific plants to warehouses as well as from specific warehouses to customers. Based on these planned shipments and the agreed rates with carrier companies, FHG budgeted the distribution costs per month. FHG learned the actual distribution costs when the carrier companies invoiced several days after the end of each month. Actual and budgeted costs almost always differed significantly, but it remained mostly unclear to FHG management why actual costs differed so much from the budget. The controlling department conducted some basic analyses comparing actual distribution costs to budget (in total, by customer, and by warehouse). The distribution management software also produced a report on several nonfinancial KPIs, which provided some indirect clues as to why actual costs differed from the budget. Overall, FHG was stuck in the dark regarding distribution costs.

With mounting cost pressure, FHG management believed distribution costs should be managed more carefully. Having recently hired Jasmine Frey as a bright new employee with a fresh perspective, she had to figure out a way to "quantify the reasons distribution costs are different from budget in any particular period," as the Chief Financial Officer (CFO) Anna Schreier had told her.

DISTRIBUTION COSTS VARIANCE ANALYSIS METHOD

Jasmine had come across a publication about variance analysis of distribution costs at the Catalyst Paper Corporation. She believed the method explained there could also be useful for FHG. The method focused on the difference between the actual distribution costs and the budgeted distribution costs and was designed for distribution networks consisting of several production plants, several warehouses, and multiple customer locations. In Catalyst's distribution network, products were first transported from a plant to a warehouse (called the first leg) and then from a warehouse to a customer location (called the last leg).

Distribution was outsourced, and Catalyst charged per unit transported for the first leg and per load transported for the last leg. Catalyst used various kinds of transportation modes such as truck and rail and several carriers for each mode. In this network, actual costs could differ from budgeted costs for a number of reasons. The method provided a systematic analysis of the cost effects of changing the mix of plants, warehouses, transportation modes, and carrier companies used to serve customer orders. Furthermore, the method quantified the cost effects of sales mix changes, price changes, and efficiency differences. More information about the method is provided in the appendix with this case.

Jasmine considered that the method of Catalyst could be very relevant for FHG, but she would need to better understand the method first. Jasmine studied the method described in the appendix, recreated the calculations provided for Catalyst, and wrote an informal report for colleagues in the finance department. FHG required documentation of how analyses were carried out, so colleagues could more easily take over each other's work and the finance department could better answer questions (for example, posed by the CFO or the auditors). Since the appendix with this case was already available, she wrote her documentation notes as additional clarifications.

CORRECTION OF THE METHOD

When investigating her calculations, Jasmine discovered an issue with the method. She accidentally changed one of the actual first-leg cost/unit rates and noticed that the sum of the calculated variances no longer equals the total cost variance. Did the method contain a mistake? By increasing, for example, the actual first-leg rate of customer record 2 from $20 to $27, the total actual costs increased to $301,820, and, thereby, the total cost variance was reduced to $34,130. This total cost variance, however, was now different from the sum of the calculated variances. Changing the actual first-leg cost/unit had not affected any of the calculated variances, and these did not add up anymore to the total cost variance.

Jasmine realized that this problem had not appeared before, because the sample data did not include any difference between an actual and a budgeted first-leg rate. Indeed, Jasmine verified that all variance calculations only depended on units (actual and budgeted), last-leg cost/load (actual and budgeted) and budgeted first-leg cost/ unit, but none of the variance calculations depended on an actual first-leg cost/ unit. Jasmine decided to investigate this problem and, if needed, to correct the method.

After having solved the problem, Jasmine felt satisfied but also a bit anxious. She wanted to make sure everything was now correct and went through the description of the method in the appendix again. She now noticed that footnote 3 mentioned another error, but this one had already been resolved.

ANALYSIS OF FHG'S DISTRIBUTION COSTS

Now that Jasmine understood the method in detail, she was convinced that it was very applicable and relevant for FHG. She downloaded information on all FHG shipments in the first month of the current year and aggregated the data according to customer records that were similar to the Catalyst example. The result is in Table 1. Please note that data in Table 1 regarding transportation modes and carriers only refer to the last leg. Jasmine calculated the same cost variances as Catalyst. She created slides for explaining the method and presenting the results in a meeting of FHG distribution managers.

REFINEMENT OF THE APPROACH FOR FHG

The presentation to managers of the distribution department had gone very well. Jasmine's colleagues liked the new variance analysis method. It was not only consistent with how they were managing distribution efficiency, but it also helped them to understand the financial consequences of their decisions. For example, Martin Fuhrmann, who planned last-leg shipments, said he tried to ship as many units as possible with each paid load, because carriers invoiced FHG on a per-load basis. He already monitored the units/load. With the new efficiency variance, he could now see the financial impact of (in)adequate use of full loads for last-leg shipments. Martin also described that he tried to use rail or barge instead of trucks whenever possible, because rail and barge transportation modes often had a lower last-leg cost/unit than trucks for the same connections. He already monitored the use of non-truck shipments. The new transportation mode mix variance showed him the financial impact of shifting to more (or less) expensive transportation modes.

Jasmine had also learned about two issues that played a role for FHG, which the new method for cost variance analysis did not yet reflect:

- *Use of FTL and LTL shipments (first leg):* FHG planed first-leg shipments and was invoiced on a per-unit basis but with different rates for less than truckload (LTL) shipments and full truck load (FTL) shipments. The rates given in Table 1 were actually weighted averages of the LTL and FLT rates. Managers would like Jasmine to isolate the financial impact of having an actual mix of FTL and LTL shipments that differed from the planned mix.
- *Rate adjustments for fuel cost (last leg):* FHG planned and ordered entire loads for last-leg distribution, and FHG was invoiced based on a cost/load. Contracting arrangements with carriers, however, provided fuel price adjustments for these cost/load rates. These adjustments were based on a publicly available fuel-price index. Consequently, the calculated last-leg rate variances were a mix of fuel price adjustments, which were allowed, and other rate variances that should not occur. Managers said they would like to see both components separately.

NONFINANCIAL KPIS AND LONG-TERM COST REDUCTION

While Jasmine was working to modify the method, she received an email from Eva Menger, FHG's supply chain director. Eva brought up two issues. The distribution department had always been monitoring several nonfinancial KPIs, and managers were used to reviewing these and comparing actuals to targets. Eva asked Jasmine to explain how each KPI in the following list was related to cost variances in the new method. In other words, if the actual score on the KPI is better or worse than the target in a particular period, which variance would be affected?

- First-leg scheduling efficiency = LTL shipments ÷ total shipments
- Last-leg load utilization = units per load
- Non-truck shipments = units shipped by rail or barge ÷ total units shipped
- Network routing efficiency = average distance from plants to customers

Second, Eva explained that FHG was under considerable cost pressure and needed to continually improve processes and reduce distribution costs from one period to the next. She asked Jasmine to address in her presentation how they could work with the new variance analysis method to support the required continuous cost reduction in the next years.

APPENDIX: DISTRIBUTION COSTS VARIANCE ANALYSIS FRAMEWORK

Catalyst Paper Corporation was based in British Columbia and manufactured pulp and paper.[1] With annual distribution costs of more than 10% of sales, senior managers at Catalyst had recognized the potential for considerable profitability improvements through better management of distribution activities. Catalyst had developed an information system that enabled detailed analysis of differences between actual costs and budgeted costs. The tool showed the impact on distribution costs of decisions regarding source plants, shipping routes, modes of transport (for example, rail vs. truck), and specific carriers used to deliver products to customers.

The company had several thousands of employees at four manufacturing plants, a paper-recycling facility, and a head office. The company annually distributed more than 2 million tons of pulp and paper products to about 1,000 customer locations directly from its manufacturing plants or through a network of more than 30 warehouses in North America, Europe, and Japan. The distribution modes used to deliver products were ship, rail, truck, barge, and intermodal.[2]

Within each mode of transportation, numerous carriers were available to meet the company's shipping requirements. For any individual customer, the specific combination of the plant used to source the order, the warehouse used to route the order, the mode of transport used to ship the goods, and the specific carrier selected could differ from one order to the next. Moreover, the costs of using different combinations of plants, warehouses, modes of transport, and carriers to serve a single customer could vary by as much as 100%. Hence, managing this complex mix of transportation alternatives was an important aspect of controlling distribution costs at Catalyst.

[1] The method is fully described in the paper by Gaffney, K., Gladkikh, V., and Webb, R. (2007). A Case Study of a Variance Analysis Framework for Managing Distribution Costs. Accounting Perspectives, 6(2), 167–190. https://doi.org/10.1506/8172-1165-6601-3L37. For preparing this teaching case, we have clarified parts of the description and implemented a few corrections. Students do not need to read the original paper.

[2] Intermodal refers to using multiple transportation modes during one particular shipment to a customer.

The method for controlling distribution costs at Catalyst includes four categories of variances:

1. Volume mix variance
2. Customer mix variances represent the impact on distribution costs of actual total sales volume and sales mix differing from budget.
3. Distribution mix variances quantify the effects of using an actual mix of plants and warehouses to source customer orders that differs from the budgeted mix, as well as the effects of different modes of transport and of different carriers within a particular mode.
4. Carrier charge variance comprises two factors: rate and efficiency. The rate variance quantifies the effect of a difference between the actual and budgeted cost per load of customer shipments. The efficiency variance represents the effect on distribution costs of a difference between the actual and budgeted number of shipments used to meet customer demand.

Table A1 presents the sample data used for our illustrative example of the variance analysis framework. Each column contains a customer record, which is created for each unique customer–warehouse–mode–carrier combination. If the same combination is used for several orders during the reporting period, the amounts in Table A1 represent totals.

Distribution from a plant to a warehouse is the first leg. Costs are incurred per unit. Although various route and mode options are possible for some warehouses, transporting products from Catalyst's plants to its warehouses (first leg) is usually done with a single mode of transport and a single carrier. Therefore, the data in Table A1 regarding transportation modes and carriers only refer to the last leg.

Distribution from a warehouse to a customer location is the last leg and costs are incurred per load. The example demonstrates that distribution alternatives are available for filling customer orders. For example, customer A can be served using warehouse 1 or 2; rail or truck can be used to transport products from warehouse 2, with two carriers to choose from if the truck mode is used.

The following notation is used for specifying the equations for the variances.

Variables include:

U units transported
L loads transported
R first-leg rate per unit
P last-leg rate ("price") per load
C last-leg cost/unit (calculated, because last-leg shipments are charged per load)
F full cost/unit (first + last leg)

Superscripts:

a actual
b budgeted

Subscripts:

t total (for all customer records)
c per customer
w per warehouse-customer combination
m per mode-warehouse-customer combination
r per carrier-mode-warehouse-customer combination, so at the level of a single customer record
p per plant-carrier-mode-warehouse-customer combination, so for each plant within a single customer record

VOLUME VARIANCE

Catalyst begins by isolating the portion of the total variance attributable to the actual number of units shipped differing from budget. The volume variance formula is as follows:

$$\text{Volume variance} = \left(U_t^a - U_t^b\right)F_t^b$$

Although selling a lower volume of products than budgeted is not favorable with regard to the overall profitability of the organization. If actual costs are less than budgeted, we present this as a favorable variance. This is consistent with management accounting practice. Note that the calculations always follow the logic of actual costs minus budgeted costs, so if actual costs are below budget, the result is a negative number. We show a favorable cost variance in parentheses or explicitly mention that the variance is favorable.

Using the data presented in Table A1 for all customers, the volume variance calculation is: (3,360 – 3,685) × $91.17 = $29,629 favorable.

CUSTOMER MIX VARIANCE

The customer mix variance represents the effect on total distribution costs of selling to a different mix of customers from the budgeted mix. To avoid confounding the customer mix variance with the impact of routing, mode and carrier choices that differ from budget, we use the total average budgeted cost per unit based on the planned mix of routing alternatives (first leg and last leg), transportation modes, and carriers. The customer mix variance formula is as follows and is calculated for each customer:

$$\text{Mix variance per customer} = F_c^b\left(\frac{U_c^a}{U_t^a} - \frac{U_c^b}{U_t^b}\right)U_t^a$$

The calculation is based on the average cost/unit of all shipments to a particular customer, and the proportions refer to the units per customer relative to all units shipped.

$$\text{Mix variance customer A} = \$90.80\left(\frac{2{,}960}{3{,}360} - \frac{2{,}885}{3{,}685}\right)3{,}360 = \$29{,}913$$

$$\text{Mix variance customer B} = \$92.50\left(\frac{400}{3{,}360} - \frac{800}{3{,}685}\right)3{,}360 = (\$30{,}474)$$

In total, 3,360 units are shipped to customers, of which 2,960 units are shipped to customer A at a budgeted average cost/unit of $90.80, and 400 units are shipped to customer B at a budgeted average cost/unit of $92.50. These actual proportions are compared to the budgeted proportions. The unfavorable variance for customer A reflects the fact that more units were sold to customer A during the period than would have been the case if the actual sales mix had been consistent with the budgeted mix. This results in actual distribution costs for customer A exceeding the budget. Fewer units, however, were sold to customer B than would have been the case if the budgeted mix had been achieved, resulting in a variance of $30,474 favorable. As with any mix variance, the total variance that is the most meaningful, which in this example is $561 favorable. This is the result of selling proportionately more units to the customer with the lower total average distribution costs (i.e., customer A).

DISTRIBUTION MIX VARIANCES

Since the customer mix variance accounts for the cost impact of shifting the mix of units between customers, the further variances are calculated within the shipments to each customer. Details of the Catalyst distribution mix variance calculations appear in Table A2.

First-leg Routing Mix Variance

Within the shipments to a particular customer, this variance quantifies the effects of using an actual mix of plants and warehouses to source customer orders that differ from the budgeted mix. The first-leg routing mix variance formula is calculated for each record and, within that, separately per plant (so for each plant-warehouse-customer combination):[3]

$$\text{First-leg routing mix variance per plant and customer record} = R_p^b\left(\frac{U_p^a}{U_c^a} - \frac{U_p^b}{U_c^b}\right)U_c^a$$

For customer record 6 in Table 1, the first-leg routing mix variance calculation is

$$\$30.00\left(\frac{300}{400} - \frac{400}{800}\right)400 + \$35.00\left(\frac{100}{400} - \frac{400}{800}\right)400 = (\$500).$$

The first-leg routing mix variance is $500 favorable for this customer–plant–warehouse combination, because proportionately more of the units shipped from warehouse 3 to customer B were supplied by plant 1 than planned (75% actual vs. 50% planned). Since plant 1 has cheaper first-leg shipping costs than plant 2, the variance is favorable for customer record 6. However, the total first-leg routing mix variance is $1,104 unfavorable (see Table A2, panel B).

Last-leg Routing Mix Variance

Within the shipments to a particular customer, the last-leg routing mix variance quantifies the effects of using an actual mix of warehouses to source customer orders that differ from the budgeted mix, holding constant the effects of different modes of transport and different carriers within a mode. To "neutralize" the impact of mode and carrier mix choices that differ from budget, the unit cost is the average budgeted last-leg cost per unit based on the planned mix of transportation modes and carriers. The last-leg routing mix variance formula for each warehouse-customer combination:

$$\text{Last-leg routing variance per warehouse-customer combination} = C_w^b\left(\frac{U_w^a}{U_c^a} - \frac{U_w^b}{U_c^b}\right)U_c^a$$

The cost/unit is specific at the level of a warehouse to a particular customer, and the proportions refer to the units per warehouse to a customer relative to all units for a particular customer. The calculation is in Table A3, Panel A: 2,960 units are shipped to customer A of which 500 units from warehouse 1 at a budgeted cost/unit of $80 and 2,460 units from warehouse 2 at a budgeted cost/unit of $69.18. These actual proportions are compared to the budgeted proportions. For customer B, all units are shipped from warehouse 3, so the actual and budgeted proportion are the same at 100%, even though the absolute units are different, and the routing mix variance for customer B is $0. The last-leg routing mix variance is $3,470 favorable, which corresponds to the total for all customer records in Table A2.

[3] We use the budgeted cost/per unit that is specific to each plant within each customer record. The formula in the paper for the first-leg routing mix variance incorrectly specifies a budgeted average cost/unit from a particular plant to a particular warehouse, so the average cost/unit for all customer records with the same plant-warehouse combination. Furthermore, we use the proportion of units shipped per plant-carrier-mode-warehouse-customer combination relative to all units shipped to the same customer. The formula in the paper uses the proportion of units shipped per plant-warehouse-customer combination relative to all units shipped to the same customer. Nevertheless, the results in Table 2 in the paper are identical to our results in Table A2.

Note that in Table A3, we calculate the variances for groups of customers records, based on the corresponding level of specificity of the cost/unit and mix proportions. In Table A2, Panel B, however, the routing mix variances are calculated for each customer record and then added up. Therefore, the sum of last-leg routing mix variances of customer records 2 to 5 in Panel B of Table A2, which concern the same warehouse-customer combination, is equal to the second component in Panel A of Table A3.

Transportation Mode Mix Variance

Within the deliveries from one warehouse to a particular customer, the transportation mode mix variance calculates the impact of using an actual mix of transport modes (for example, rail and truck) for getting products from the warehouses to the customer destinations that differs from the budget, holding constant the effects of different carriers within a mode. This only applies to customer records that show such variation of transportation modes within the shipments for a particular warehouse to a particular customer. The calculation is as follows:

$$\text{Mode mix variance per mode-warehouse-customer combination} = C_m^b \left(\frac{U_m^a}{U_w^a} - \frac{U_m^b}{U_w^b} \right) U_w^a$$

The cost/unit is specific to a transportation mode from a particular warehouse to a particular customer, the proportions are the units per mode-warehouse-customer combination relative to the total units shipped from that warehouse to that customer. The calculation of the mode mix variance is in Table A3, Panel B: 2,460 units are transported from warehouse 2 to customer A, of which 360 units are transported by rail at a cost/unit of $50 and 2,100 units are transported by truck at a budgeted cost/unit of $70. These actual proportions are compared to the budgeted proportions. The last-leg mode variance is ($5,194), which corresponds to the total for all customer records in Table A3.

Note that the second component in Panel B of Table A3 is equal to the sum of mode mix variances of customer records 3 to 5 in Panel B of Table A2, which concern the same mode-warehouse-customer combination.

Carrier Mix Variance

Within the deliveries using a particular transportation mode from a particular warehouse to a particular customer, the carrier mix variance represents the effects of using a different mix of carriers (for example, different trucking companies). This only applies to customer records that have various carriers for the same mode-warehouse-customer combination. The calculation is as follows for each carrier-mode-warehouse-customer combination:

$$\text{Carrier mix variance} = C_r^b \left(\frac{U_r^a}{U_m^a} - \frac{U_r^b}{U_m^b} \right) U_m^a$$

The cost/unit is specified per carrier company, and the proportions are carrier companies per transportation mode from a particular warehouse to a particular customer. Panel C of Table A3 shows the calculation of the carrier mix variance: 2,100 units are transported by truck from warehouse 2 to customer A, of which 1,400 units are transported by carrier 2 at a cost/unit of $70, etc.

CARRIER CHARGE VARIANCES

Carrier charge variance consist of two factors: rate and efficiency. Details of the Catalyst carrier charge variance calculations appear in Table A2.

Rate variance

The rate variance quantifies the effect of a difference between the actual and budgeted cost per load of customer shipment and is calculated as follows for each customer record:

$$\text{Rate variance} = (P_r^a - P_r^b)L_r^a$$

For customer record 2 in Table A1, for example, the rate variance is: ($4,320 – $4,250) × 5 = $350 unfavorable.

Efficiency Variance

The efficiency variance represents the effect on distribution costs of a difference between the actual and budgeted number of shipments used to meet customer demand. In other words, the distribution cost efficiency variance reflects how well management utilized transportation capacity during the period. The general idea of the efficiency variance for the use of a particular resource:

Efficiency variance = (actual quantity - standard quantity given actual volume) × standard price

Here, quantity concerns the number of loads, and the standard quantity is adjusted—reflecting the idea of the flexible budget based on the actual units shipped. This variance is calculated as follows for each customer record:

$$\text{Efficiency variance} = \left(L_r^a - \frac{U_r^a}{U_r^b}L_r^b\right)P_r^b$$

For customer record 2 (the only record showing an efficiency variance), the efficiency variance is: (5 – (360÷85) × 1) × $4,250 = $3,250 unfavorable.

In other words, given the budgeted units/load and the actual units shipped, how many loads should have been? This is compared to the actual number of loads used. The difference in the number of loads × the budgeted cost/load = efficiency variance. For customer record 2 with budgeted 85 units/load and actual 360 units, the standard #loads is 4, and the actual #loads is 5, so the difference of 1 load yields an efficiency variance of 1 × $3,250 budgeted cost/load = $3,250 unfavorable.

SUMMARY

The results for all Catalyst variances are also shown in Figure A1 and Figure A2. The per-unit amounts included in Figure A2 for each variance category are calculated by dividing the variance from Table A2, Panel B, by the actual total number of units sold during the period. For example, the mode mix variance of $1.55/unit is equal to $5,194/3,360. Catalyst employs this approach in its reporting of variances each period.

Table 1. FHG Customer Records for the First Month of the Current Year

Panel A: Actual amounts																*Total*	*Average*
Customer record	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Customer	A	A	A	A	A	A	A	B	B	A	A	B	B	C	C		
Warehouse	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4		
Transport mode (last leg)	Truck	Truck	Truck	Rail	Rail	Barge	Truck	Truck	Truck	Truck	Rail	Rail	Rail	Rail	Rail		
Carrier (last leg)	Truck-1	Truck-2	Truck-3	Rail-1	Rail-2	Barge-1	Truck-2	Truck-3	Truck-4	Truck-1	Rail-2	Rail-2	Rail-3	Rail-3	Rail-3		
Loads shipped (last leg)	25	0	0	5	10	1	70	30	4	75	8	8	5	20	10	271	
Units shipped																	
Plant 1	500	0	0	360	200		1.000	600	100	1.200	650	650	300			5.560	
Plant 2					600	200	400			400			100	1.500	800	4.000	
Total units shipped	500	0	0	360	800	200	1.400	600	100	1.600	650	650	400	1.500	800	9.560	
Cost per load (last-leg)	$1.660	$1.700	$1.650	$4.378	$4.000	$8.240	$1.442	$1.300	$1.875	$1.545	$4.900	$4.900	$4.944	$7.300	$7.725		
First-leg cost/unit																	
Plant 1	$16,00	$15,50	$19,00	$21,00	$19,00		$20,00	$19,00	$20,00	$33,00	$36,00	$32,00	$30,00				
Plant 2					$20,00	$20,00	$20,00			$46,00			$37,00	$52,00	$53,00		
Last-leg cost/unit	$83,00	$89,05	$90,00	$60,81	$50,00	$41,20	$72,10	$65,00	$75,00	$72,42	$60,31	$60,31	$61,80	$97,33	$96,56		
Total cost/unit	$99,00	$104,55	$109,00	$81,81	$69,75	$61,20	$92,10	$84,00	$95,00	$108,67	$96,31	$92,31	$93,55	$149,33	$149,56		
First-leg total costs	$8.000	$0	$0	$7.560	$15.800	$4.000	$28.000	$11.400	$2.000	$58.000	$23.400	$20.800	$12.700	$78.000	$42.400	$312.060	$32,64
Last-leg total costs	$41.500	$0	$0	$21.890	$40.000	$8.240	$100.940	$39.000	$7.500	$115.875	$39.200	$39.200	$24.720	$146.000	$77.250	$701.315	$73,36
Total costs	$49.500	$0	$0	$29.450	$55.800	$12.240	$128.940	$50.400	$9.500	$173.875	$62.600	$60.000	$37.420	$224.000	$119.650	**$1.013.375**	$106,00

Panel B: Budgeted amounts																	
Customer record	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Customer	A	A	A	A	A	A	A	B	B	A	A	B	B	C	C		
Warehouse	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4		
Transport mode (last leg)	Truck	Truck	Truck	Rail	Rail	Barge	Truck	Truck	Truck	Truck	Rail	Rail	Rail	Rail	Rail		
Carrier (last leg)	Truck-1	Truck-2	Truck-3	Rail-1	Rail-2	Barge-1	Truck-2	Truck-3	Truck-4	Truck-1	Rail-2	Rail-2	Rail-3	Rail-3	Rail-3		
Loads shipped (last leg)	40	11	6	1	10	5	100	0	0	75	5	5	10	4	4	276	
Units shipped																	
Plant 1	800	210	110	85	200		2.000	0	0	1.200	400	400	400			5.805	
Plant 2					800	1.000	10			400			400	300	300	3.210	
Total units shipped	800	210	110	85	1.000	1.000	2.010	0	0	1.600	400	400	800	300	300	9.015	
Cost per load (last-leg)	$1.600	$1.700	$1.650	$4.250	$3.900	$8.000	$1.400	$1.300	$1.875	$1.500	$4.800	$4.800	$4.800	$7.000	$7.500		
First-leg cost/unit																	
Plant 1	$15,00	$15,50	$19,00	$20,00	$20,00		$20,00	$19	$20	$35,00	$35,00	$30,00	$30,00				
Plant 2					$20,00	$20,00	$20,00			$45,00			$35,00	$50,00	$50,00		
Last-leg cost/unit	$80,00	$89,05	$90,00	$50,00	$39,00	$40,00	$69,65	$65,00	$75,00	$70,31	$60,00	$60,00	$60,00	$93,33	$100,00		
Total cost/unit	$95,00	$104,55	$109,00	$70,00	$59,00	$60,00	$89,65	$84,00	$95,00	$107,81	$95,00	$90,00	$92,50	$143,33	$150,00		
First-leg total costs	$12.000	$3.255	$2.090	$1.700	$20.000	$20.000	$40.200	$0	$0	$60.000	$14.000	$12.000	$26.000	$15.000	$15.000	$241.245	$26,76
Last-leg total costs	$64.000	$18.700	$9.900	$4.250	$39.000	$40.000	$140.000	$0	$0	$112.500	$24.000	$24.000	$48.000	$28.000	$30.000	$582.350	$64,60
Total costs	$76.000	$21.955	$11.990	$5.950	$59.000	$60.000	$180.200	$0	$0	$172.500	$38.000	$36.000	$74.000	$43.000	$45.000	**$823.595**	$91,36

Table A1. Catalyst Sample Data

Panel A: Actual amounts							*Total*	*Average*
Customer record	1	2	3	4	5	6		
Customer	A	A	A	A	A	B		
Warehouse	1	2	2	2	2	3		
Transport mode (last leg)	Truck	Rail	Truck	Truck	Truck	Rail		
Carrier (last leg)	Truck-1	Rail-1	Truck-2	Truck-3	Truck-4	Rail-2		
Loads shipped (last leg)	25	5	70	30	4	5	139	
Units shipped	0	0	0	0	0	0		
Plant 1	500	360	1.400	600	100	300	3.260	
Plant 2	0	0	0	0	0	100	100	
Total units shipped	500	360	1.400	600	100	400	3.360	
Cost per load (last leg)*	$1.600	$4.320	$1.400	$1.300	$1.875	$4.800		
First-leg cost/unit**								
Plant 1	$15,00	$20,00	$20,00	$20,00	$20,00	$30,00		
Plant 2	$0,00	$0,00	$0,00	$0,00	$0,00	$35,00		
Last-leg cost/unit	$80,00	$60,00	$70,00	$65,00	$75,00	$60,00		
Total cost/unit	$95,00	$80,00	$90,00	$85,00	$95,00	$91,25		
First-leg total costs	$7.500	$7.200	$28.000	$12.000	$2.000	$12.500	$69.200	$20,60
Last-leg total costs	$40.000	$21.600	$98.000	$39.000	$7.500	$24.000	$230.100	$68,48
Total costs	$47.500	$28.800	$126.000	$51.000	$9.500	$36.500	**$299.300**	$89,08

Panel B: Budgeted amounts								
Customer record	1	2	3	4	5	6		
Customer	A	A	A	A	A	B		
Warehouse	1	2	2	2	2	3		
Transport mode (last leg)	Truck	Rail	Truck	Truck	Truck	Rail		
Carrier (last leg)	Truck-1	Rail-1	Truck-2	Truck-3	Truck-4	Rail-2		
Loads shipped (last leg)	40	1	100	0,000000003	0,0000000004	10	151	
Units shipped	0	0	0	0	0	0		
Plant 1	800	85	2.000	0,00000006	0,0000000100	400	3.285	
Plant 2	0	0	0	0	0	400	400	
Total units shipped	800	85	2.000	0	0	800	3.685	
Cost per load (last leg)*	$1.600	$4.250	$1.400	$1.300	$1.875	$4.800		
First-leg cost/unit**								
Plant 1	$15,00	$20,00	$20,00	$20,00	$20,00	$30,00		
Plant 2	$0,00	$0,00	$0,00	$0,00	$0,00	$35,00		
Last-leg cost/unit	$80,00	$50,00	$70,00	$65,00	$75,00	$60,00		
Total cost/unit	$95,00	$70,00	$90,00	$85,00	$95,00	$92,50		
First-leg total costs	$12.000	$1.700	$40.000	$0	$0	$26.000	$79.700	$21,63
Last-leg total costs	$64.000	$4.250	$140.000	$0	$0	$48.000	$256.250	$69,54
Total costs	$76.000	$5.950	$180.000	$0	$0	$74.000	**$335.950**	$91,17

* Last-leg costs are incurred on a per load basis, regardless of the number of units shipped.

** First-leg costs are incurred on a per unit basis.

Note: Sample data used for an illustrative example of the variance analysis framework. Catalyst's distribution activity in one month consists typically of many more customer records, which include a larger number of different customers, warehouses, transportation modes, and carriers. Source: Gaffney, et al. (2007), reused with permission. © 2007 Canadian Academic Accounting Association

Table A2. Details of Catalyst Distribution Mix and Carrier Charge Variance Calculations

Panel A: Average budgeted cost/unit used in variance calculations

Cost/unit for last-leg mix variances	
Warehouse 1 to Customer A (all modes)	$80,00
Warehouse 2 to Customer A (all modes)	$69,18
Warehouse 3 to Customer B (all modes)	$60,00
Cost/unit for mode-mix variances	
Warehouse 1 to Customer A (truck)	$80,00
Warehouse 2 to Customer A (truck)	$70,00
Warehouse 2 to Customer A (rail)	$50,00
Warehouse 3 to Customer B (rail)	$60,00

Panel B: Distribution mix and carrier charge variances (favorable variances in parentheses)

Customer record	1	2	3	4	5	6	
Customer	A	A	A	A	A	B	
Warehouse	1	2	2	2	2	3	
Transport mode (last leg)	Truck	Rail	Truck	Truck	Truck	Rail	
Carrier (last leg)	Truck-1	Rail-1	Truck-2	Truck-3	Truck-4	Rail-2	
Distribution mix variances							
First-leg mix	($4.812)	$5.456	($13.040)	$12.000	$2.000	($500)	$1.104
Last-leg mix	($25.664)	$18.873	($45.108)	$41.511	$6.918	$0	($3.470)
Mode mix		$12.986	($67.180)	$42.000	$7.000		($5.194)
Carrier mix			($49.000)	$39.000	$7.500		($2.500)
Total distribution mix	($30.476)	$37.314	($174.328)	$134.511	$23.418	($500)	($10.060)
Carrier charge variances							
Rate	$0	$350	$0	$0	$0	$0	$350
Efficiency	$0	$3.250	$0	$0	$0	$0	$3.250
Total carrier charge	$0	$3.600	$0	$0	$0	$0	$3.600

Note: Based on the sample data in Table A1. Source: Gaffney, et al. (2007), reused with permission. © 2007 Canadian Academic Accounting Association

Table A3. Catalyst Nested Mix Variance Calculations

$$\text{Budgeted cost per unit} \times \left(\text{Actual proportion} - \text{Budgeted proportion}\right) \times \text{Actual total units} = \text{Mix variance}$$

Panel A: Last-leg mix variance (favorable variances in parentheses)
Cost/unit: specific per warehouse-customer combination
Proportion: units per warehouse for a particular customer, relative to total volume per customer

	Budgeted cost per unit	Actual proportion	Budgeted proportion	Actual total units	Mix variance
Warehouse 1 to customer A	$80,00	500 / 2.960	800 / 2.885	2.960	($25.664)
Warehouse 2 to customer A	$69,18	2.460 / 2.960	2.085 / 2.885	2.960	$22.194
Warehouse 3 to customer B	$60,00	400 / 400	800 / 800	400	$0
		3.360	3.685		($3.470)

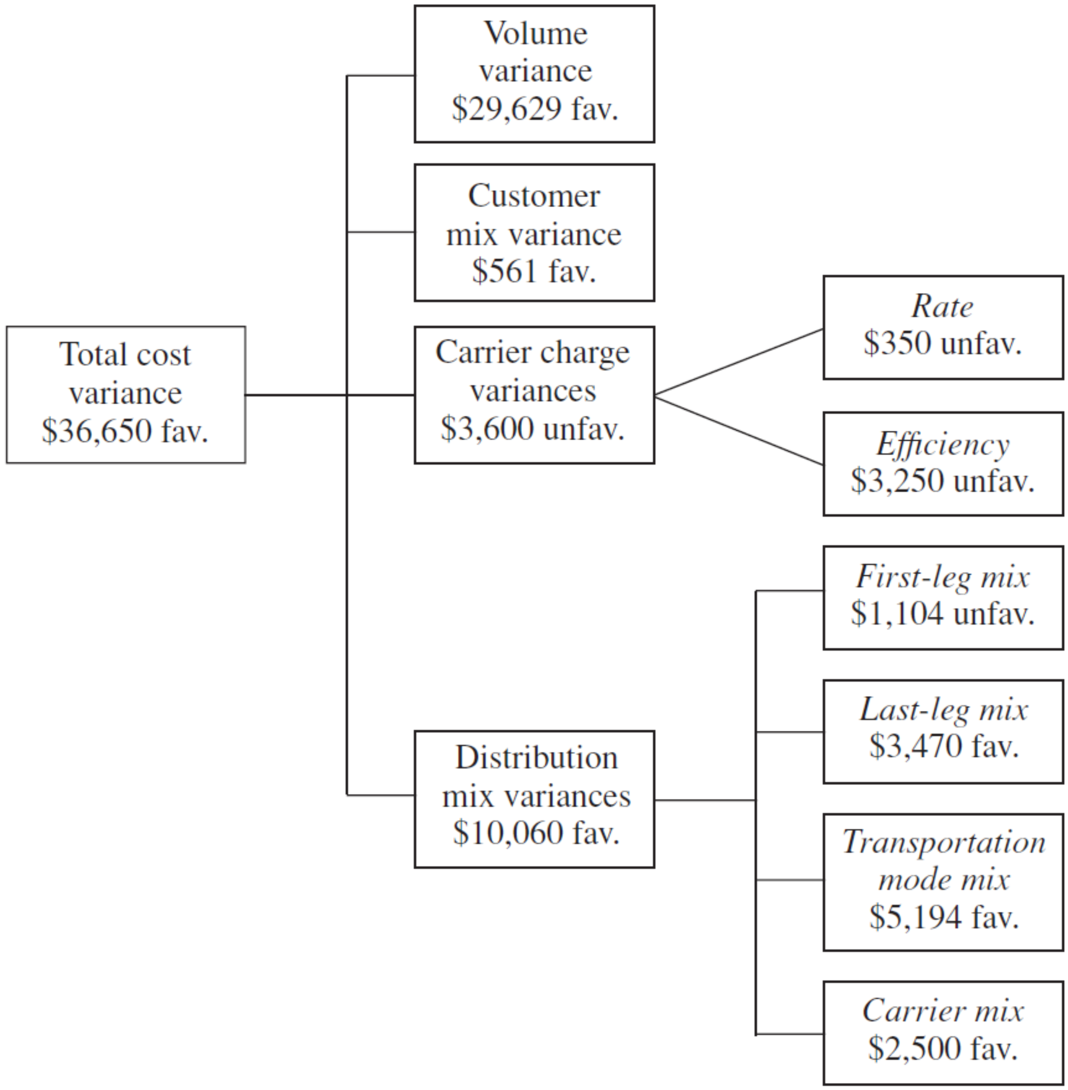
Panel B: Mode mix variance
Cost/unit: specific per mode-warehouse-customer combination
Proportion: units per mode from a particular warehouse to a particular customer,
relative to total units from that warehouse to that customer

	Budgeted cost per unit	Actual proportion	Budgeted proportion	Actual total units	Mix variance
Rail, Wareh 2 to Cust A	$50,00	360 / 2.460	85 / 2.085	2.460	$12.986
Truck, Wareh 2 to Cust A	$70,00	2.100 / 2.460	2.000 / 2.085	2.460	($18.180)
		2.460	2.085		($5.194)

Panel C: Carrier mix variance
Cost/unit: specific per carrier-mode-warehouse-customer combination
Proportion: units per carrier from a particular warehouse to a particular customer,
relative to all units with that mode from that warehouse to that customer

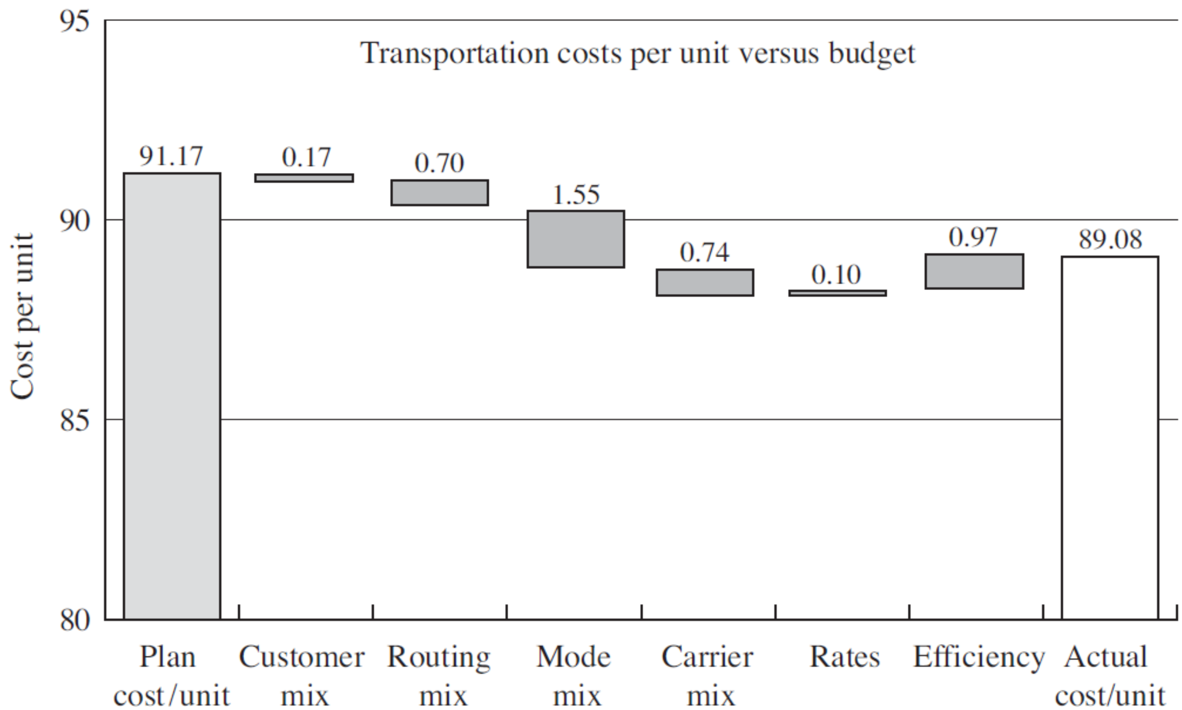
	Budgeted cost per unit	Actual proportion	Budgeted proportion	Actual total units	Mix variance
Carrier 2, Truck, Wareh 2, Cust A	$70,00	1.400 / 2.100	2.000 / 2.000	2.100	($49.000)
Carrier 3, Truck, Wareh 2, Cust A	$65,00	600 / 2.100	0 / 2.000	2.100	$39.000
Carrier 4, Truck, Wareh 2, Cust A	$75,00	100 / 2.100	0 / 2.000	2.100	$7.500
		2.100	2.000		($2.500)

Figure A1. Variance Summary Catalyst



Note: Based on the sample data in Table A1. See Table A2 for details of the distribution mix and carrier charge variances. Source: Gaffney, et al. (2007), reused with permission. © 2007 Canadian Academic Accounting Association

Figure A2. Summary Reporting of Catalyst Variances



Note: Based on the sample data in Table A1. The variance per unit is calculated by dividing the dollar variance amounts by the actual total units delivered for the period (3,360). The routing variance is the sum of the first-leg and last-leg variances. Source: Gaffney et al. (2007), reused with permission. © 2007 Canadian Academic Accounting Association