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AN APPLICATION OF ACTIVITY BASED COSTING IN THE AIR CONDITIONER MANUFACTURING INDUSTRY

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AIRCO is a manufacturer of industrial air conditioner units whose management is concerned that their current traditional cost accounting (TCA) system is not accurately representing their product cost behavior. Under certain operating conditions, an activity based costing (ABC) system can provide relevant and accurate indirect cost information that assists in making customer, product, and process improvement decisions. An ABC system was successfully developed for AIRCO that indicated that their products do not consume overhead costs on a volume basis as represented by their current TCA system. Valuable product and process information were obtained. This case study details the development process that was used and the results that were obtained during the ABC analysis.

INTRODUCTION

Activity-based costing (ABC) has helped many manufacturing and services organizations improve their competitiveness by enabling them to make better decisions based on an improved understanding of their product cost behavior. The main premise behind ABC is to classify overhead or indirect costs and to allocate them to end products or services based upon the activities required to produce these products (Raz & Elnathan, 1999). ABC takes a two-stage approach to allocating overhead costs to products based on multiple cost drivers at various levels of activity. In the first stage, overhead costs are assigned to cost pools within an activity center based upon activity-driven cost drivers. There is no

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equivalent step in traditional costing accounting (TCA). In the second stage, overhead costs are allocated from the cost pools to the products based on the product's consumption of indirect activities. This stage is similar to TCA except that the traditional approach uses a single volume-based cost driver to allocate overhead costs to products without consideration for non-volume-related characteristics. ABC was pioneered in the late 1980s by Cooper (1988a, 1988b, 1999a, 1999b), Cooper and Kaplan (1998a, 1998b), and Johnson and Kaplan (1987). Experts believe that ABC can provide more accurate product costing information than TCA when products are diverse in size, complexity, material requirements, and/or setup procedures (Cooper & Kaplan, 1988). A costing system should provide users with relevant and accurate information that will assist them in making decisions such as product pricing, customer and product profitability analysis, and process improvement. This case study details an ABC system that was developed for a manufacturer of industrial air conditioner units (referred to here as AIRCO for confidentiality purposes). AIRCO believed that their current TCA system was not accurately representing their product cost behavior and wanted to invest time and effort into developing an ABC system to seek improved product costing information.

COMPANY DESCRIPTION

Located in Arkansas, AIRCO produces and sells high quality, high-end industrial air conditioner units to a wide variety of customers. The company has exhibited moderate growth during its 25-year existence. An increased number of product lines over the years have been supported by increasing the number of machines, workstations, and assembling lines. In addition, the number of operators and material handlers involved in the production process has increased. An information support team was introduced to support the use of computerized production planning and data management systems.

AIRCO produces a variety of industrial air conditioner units that range in power from 5 to 20 tons. Each unit consists of more than 200 parts including tubes, wires, metal sheets, cooling coils, insulation materials, controlling processor, and freon holding tanks. Some parts are manufactured in-house, while others are purchased from outside suppliers.

There are currently more than 460 employees working for AIRCO. Eighty-eight percent of them are hourly workers; the remaining 12% are classified as salaried employees. AIRCO operates two shifts per day, 7:30 AM to 4:30 PM and 4:00 PM to 12:00 AM. The majority of

TABLE 1. Salaried Employment Data

Employment	Annual salary ($)	# Employed	Total ($)
Plant manager	100,000	1	100,000
Engineering dept.	40,000	19	760,000
Finance dept.	31,500	5	157,500
Purchasing dept.	31,500	4	126,000
Material control dept.	26,500	6	159,000
Human resources dept.	26,500	4	106,000
Scheduling & management dept.	26,500	4	106,000
Shipping & packaging dept.	26,500	6	159,000
Department managers	65,000	7	455,000
Secretary	22,000	2	44,000
Total		58	2,172,500

workers (70%) are employed during the first shift. Direct laborers are broken down into 280 skilled and 80 unskilled workers, whose hourly rates are $18 and $14, respectively. AIRCO also employs 32 indirect laborers at an hourly rate of $10, who perform material handling and other support activities. The employment of these hourly workers cost AIRCO $11,827,200 in direct labor and $614,400 in indirect labor last year. Table 1 contains salary data for AIRCO's salaried employees.

COMPANY STRUCTURE

AIRCO is structured into seven departments as shown in Figure 1. Each department is managed by a department manager who works closely with upper plant management. In addition, the assembly & testing and fabrication areas are overseen by workstation and line supervisors.

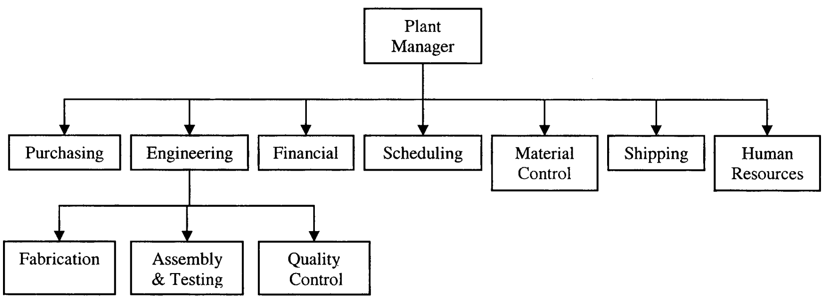

FIGURE 1. AIRCO organizational structure.

Purchasing Department

The primary responsibility of the purchasing department is the selection of vendors that perform best in terms of cost, quality, and services. The purchasing department also monitors the arrival of raw materials to the factory, maintains the inventory levels of these materials, and manages scrap materials.

Engineering Department

The engineering department is divided into three functional areas: fabrication, assembly & testing, and quality control. This department is responsible for improving production processes, designing tools, and redesigning products according to customer specification. The fabrication and assembly & testing areas are responsible for fabricating parts, assembling parts, monitoring production operators, maintaining machines, and testing final products. The quality control area is responsible for ensuring final product quality, performing quality studies, and processing customer complaints regarding product quality.

Financial Department

The financial department is responsible for maintaining the integrity of all financial data. This department also tracks the expenditures of all seven departments and ensures that departmental spending is within budgetary limitations. Furthermore, the department maintains wage rates for hourly and salaried employees.

Scheduling Department

The key functions of the scheduling department are to forecast product demand, collect and analyze production data at the shop floor level, monitor inventory levels, and manage work-in-process.

Material Control Department

This department is responsible for determining and handling materials according to specified orders, maintaining and monitoring delivery time, completing purchase orders, negotiating the price of the materials with the suppliers, and finding new material sources. The material control department plays an important role in decreasing costs and assuring availability of material through monitoring vendor performance in terms of cost, delivery, and quality. The department is also responsible for selecting vendors, inspecting materials, verifying quantities received, and recording material receipts and payments in cooperation with the financial department.

Shipping Department

The shipping department is primarily responsible for selecting the transportation mode for product delivery and route scheduling and ensuring that the correct products are delivered on time to the correct customer.

Human Resources Department

The human resources department is responsible for handling personnel issues, monitoring manpower fluctuations, and ensuring that company activities operate within government regulations such as OSHA and mandatory training.

ACTIVITY-BASED COSTING SYSTEM DESIGN

The ABC system for AIRCO was developed using a five step process: 1) identification of overhead cost categories, 2) identification of cost pools and drivers, 3) assignment of overhead costs to cost pools, 4) product data collection, and 5) final ABC analysis. The development process and results of each of these five steps are described in this section.

Identification of Overhead Cost Categories

Identifying the overhead cost categories is the first and one of the most important steps in developing an ABC system. Expenses vary from department to department as most departments perform distinct job functions with various consumptions of indirect resources. It is vital to investigate each department separately and identify what indirect resources are consumed and by how much. Most of the indirect resources at AIRCO are consumed by supplying power to machines, machine maintenance, wages paid to indirect laborers, computer and software systems, and marketing. Additional overhead costs include rent for facilities and vehicles, transportation costs including the transport of raw material purchases to the warehouses, customer service, and data management. Table 2 contains the major indirect expense categories and amounts for

TABLE 2. Overhead Cost Categories

Overhead category	Cost ($)
Indirect labor	2,786,900
Computer & software	731,405
Product transportation	319,800
Energy	170,600
Facility & vehicle rent	165,870
Business & training travel	66,000
Miscellaneous	65,480
Maintenance	60,000
Depreciation	48,200
Advertising	40,000
Office & utilities	4,350
Total	4,458,605

AIRCO. Observation of Table 2 shows that the total overhead cost incurred by AIRCO last year was $4,458,605.

The miscellaneous category includes indirect costs that are difficult to map to particular activities. These costs will be mapped to the activities using educated guesses based on opinion and experience of AIRCO employees.

Identification of Cost Pools and Drivers

In practice, one can identify a large number of activities performed to produce end products (Cooper et al., 1992). For example, a setup punching machine process can be decomposed into numerous micro-activities such as identifying tools required, cutting tools for each shape and size, going to tool crib, selecting the tool, bring tool to the machine, etc. Such a detailed process description is rarely practical in the development of an ABC system. If too many activities are defined, the cost of measurement for the ABC system grows disproportionately high (Cooper et al., 1992). Activities should be aggregated into cost pools based on similar cost driver behavior. Table 3 shows the eight cost pools that were identified as primary indirect activities for AIRCO. These cost pools were developed from examination of overhead-related data, cost driver analysis, and employee interviews.

Two factors drive the cost of measurement associated with the number of cost pools in an ABC system. The first one is that the system designer must specify the resources consumed by each activity and how many times the same activity is used for the same output. If the number

TABLE 3. Cost Pools and Drivers

Cost pool	Cost driver
Machines	Number of machine hours
Data record maintenance	Number of products administered
Material handling	Number of products
Product changeover	Setup time (hours)
Scheduling & production preparation	Number of production runs
Raw material receiving & handling	Number of receipts
Product shipment	Distance (miles)
Customer service	Number of customer contacts

of outputs is high, identifying numerous activities can lead to a huge data collection task. Second, as the number of cost pools gets larger, the activity–output relationships become more difficult and costly to measure. In order to reduce complexity, key activities that are most important and highly related to indirect resource consumption should be identified.

Machines are the primary equipment used in the production and fabrication of parts and their assembly. Maintaining data records for all products, designs, and customers is an important activity and was found to be driven by the number of products administered. Material handling involves the movement of parts throughout the production and assembly processes. This activity consumes a significant amount of indirect labor hours as it is currently performed manually at AIRCO. This manual movement of materials is thought to be inefficient and may warrant adoption of an automatic conveying system to move parts and material within the facility. AIRCO produces multiple product lines that vary in design and volume; therefore, multiple changeovers occur as machines are set up between production runs. Scheduling and production preparation is driven by the number of production runs as the number of production runs and associated scheduling and preparation activities increase due to increases in customer orders. Receiving raw materials and outsourced parts is an important activity that must be considered, as it consumes a lot of indirect labor. This activity also requires vehicles to transport the material and administrative assistance in scheduling and preparation receipts, contacting suppliers, and managing warehouses. Final products must be shipped on time to customers in order to avoid penalties and reduce inventory costs. AIRCO customers are located throughout the United States, and therefore product shipping costs depend on the distance traveled. There are frequently interactions with customers that occur between the time that the contract is signed and the final products are delivered as customers request design changes and production status information.

Assignment of Overhead Costs to Cost Pools

Once the cost pools have been identified, indirect resources must be mapped to these cost pools according to the rate in which their associated activities consume these resources. Indirect resource consumption can be assigned to activities in three ways: direct charging, estimation, and arbitrary allocation (Cooper et al., 1992). Direct charging involves the measurement and tracking of the actual consumption of the resources by the activities. This method requires large investments of time and effort and is rarely practical or economically justified. ABC system designers typically estimate the resources consumed by each activity cost pool through surveys and interviews of key personnel (Cooper et al., 1992). For example, the AIRCO fabrication department manager was asked about the time required to set up machines between new production runs. Roztocki et al. (1999) provide an efficient and systematic method for estimating cost pool resource consumption through the use of an expense activity dependence matrix. Table 4 contains the expense activity dependence matrix that was developed for AIRCO, where the cost pools are the rows ($i = 8$) and the overhead cost categories are the columns ($j = 11$). The value of each cell_{ij} (resource consumption rate) represents the percent at which cost pool i consumes indirect resource j. These percentages must sum to one for each column. To calculate the total amount consumed by each cost pool, each resource consumption rate is multiplied by the value of the resource and then summed across each category. An example calculation for the machines cost pool is provided below:

$$\begin{aligned}
&\text{Overhead Cost for Machines Cost Pool}\\
&\quad = (0.2 \times \$731{,}405) + (1 \times \$170{,}600) + (0.15 \times \$65{,}480)\\
&\qquad + (1 \times \$60{,}000) + (1 \times \$48{,}200) + (0.12 \times \$4{,}350)\\
&\quad = \$435{,}425
\end{aligned}$$

When it is extremely difficult or impossible to estimate the resources consumed by the activity cost pools, designers must resort to arbitrary allocations. The use of arbitrary allocation should be minimized as it does not provide understanding of the economic behavior of overhead activities.

TABLE 4. Expense Activity Dependence Matrix

	Overhead cost category										
Activity cost pools	Indirect labor	Computer & software	Product transportation	Energy	Facility & vehicle rent	Business & training travel	Miscellaneous expenses	Maintenance	Depreciation	Advertising	Office & utilities
Machines		0.2		1			0.15	1	1		0.12
Data record maintenance	0.03	0.06					0.07				0.12
Material handling	0.55	0.025					0.13				0.1
Product changeover	0.25	0.03					0.07				0.02
Scheduling & production preparation		0.025					0.1				0.01
Raw material receiving & handling	0.09	0.6	0.35		0.4		0.13				0.15
Product shipment	0.08	0.03	0.65		0.6		0.12				0.2
Customer service		0.03				1	0.23			1	0.28

Since machines consume most of the electricity, and other electricity consumption such as lighting and climate control is assumed to be negligible in comparison, all the energy expenses are assumed to be consumed by the machines cost pool. In addition, the machines cost pool is consuming all of the depreciation and maintenance expenses and a large amount of the computer and software and miscellaneous resources. Thirty-five percent of the transportation costs are assigned to raw material receiving & handling, while the remaining 65% are consumed in product shipping. Forty percent of facility and vehicle rent is used in material receiving & handling; the remaining 60% is used in shipping finished goods to customer destinations. All business travel and advertising costs are consumed by customer service. Indirect labor is consumed across five cost pools with the majority consumed by the material handling cost pool (55%). There are various consumptions of computer & software and office & utilities resources among the cost pools. Miscellaneous expenses were assigned to cost pools based upon employee approximation and educated guesses. Table 5 contains the resulting overhead cost of each AIRCO cost pool. Observation of Table 5 indicates that the majority of overhead costs is being incurred by the material handling and raw material receiving & handling cost pools. This confirms AIRCO's suspicion that their material handling processes are inefficient and supports investigation into the economic feasibility of implementing automatic material handling systems.

Product Data Collection

AIRCO manufactures seven distinct product types, which can be classified according to their power specifically 5-ton, 6-ton, 7.5-ton, 10-ton, 12.5-ton, 15-ton, and 20-ton. Production volume, unit selling price, direct costs, and cost driver levels for each product type were collected and are provided in Table 6.

TABLE 5. Cost Pool Overhead Cost

Cost pool	Overhead cost ($)
Machines	435,425.00
Data record maintenance	132,596.90
Material handling	1,560,027.53
Product changeover	723,337.75
Scheduling & production preparation	24,876.63
Raw material receiving & handling	877,106.90
Product shipment	561,013.75
Customer service	144,220.55

TABLE 6. Product Data by Type

Cost parameter	Products							
	5-ton	6-ton	7.5-ton	10-ton	12.5-ton	15-ton	20-ton	Total
Production volume	2983	1326	4192	4198	935	1149	2089	16,872
Unit selling price ($)	1000	1300	1750	2460	3420	4572	5450	19,952
Material cost/unit ($)	665	665	665	1957	1957	2510	2510	10,929
Direct labor hours/unit	20	20	20	24	24	24	24	156
Total direct labor hours	59,660	26,520	83,840	100,752	22,440	27,576	50,136	370,924
Direct labor cost/unit ($)	342.20	342.20	342.20	410.64	410.64	410.64	410.64	2669.20
Machine hours/unit	3.36	3.36	3.36	4.96	4.96	6.13	6.13	32.26
# of machine hours	10,023	4455	14,085	20,822	4638	7043	12,806	73,872
# of products administered	2	2	2	2	2	2	2	14
Setup time (hours)	8	8	8	12	12	12	12	72
# of production runs	153	600	240	120	654	570	451	2788
# of receipts	184	700	200	150	845	178	602	2859
Distance (miles)	500,000	900,000	600,000	500,000	10,000,000	700,000	584,015	13,784,015
# of customer contacts	150	547	245	120	654	347	470	2533

TABLE 7. ABC Overhead Rates

Cost pool	Overhead cost ($)	Cost driver total ($)	Overhead rate ($/driver)
Machines	435,425.00	73,872	5.89
Data record maintenance	132,596.90	14	9471.21
Material handling	1,560,027.53	16,872	92.46
Product changeover	723,337.75	72	10,046.36
Scheduling & production preparation	24,876.63	2788	8.92
Raw material receiving & handling	877,106.90	2859	306.79
Product shipment	561,013.75	13,784,015	0.04
Customer service	144,220.55	2533	56.94

ABC Analysis

The overhead rate for each cost pool was computed by dividing the total overhead cost of each cost pool (from Table 5) by its associated total cost driver level. The cost driver level for each cost pool are computed from the sum of the individual products' cost driver levels as given in the total column of Table 6. This data was collected from departmental records and employee interviews. The resulting ABC overhead rates are shown in Table 7.

The next step is to calculate the unit overhead cost of each product. For each product type, this was done by multiplying each ABC overhead rate by its cost driver value and then dividing it by the product's production volume. Table 8 provides the ABC overhead costs for each product by cost pool, which were then totaled to provide the ABC overhead costs for each of the seven products.

The last step in the ABC analysis is to compute the total product costs by summing the direct labor cost, direct material cost, and overhead cost of each product. A profit/loss analysis for each product was performed by comparing the ABC product costs to the each product's selling prices. The final ABC results are presented in Table 9.

Table 9 shows that the 5-ton, 6-ton, and 12.5 ton units are unprofitable at their current selling prices. The 10-ton unit is barely profitable, and the 7.5-ton, 15-ton, and 20-ton units are quite profitable and could survive competitively driven price cuts if necessitated.

TABLE 8. ABC Overhead Costs

Cost pool	Product overhead cost ($)						
	5-ton	6-ton	7.5-ton	10-ton	12.5-ton	15-ton	20-ton
Machines	19.80	19.80	19.80	29.24	29.24	36.13	36.13
Data record maintenance	6.35	14.29	4.52	4.51	20.26	16.49	9.07
Material handling	92.46	92.46	92.46	92.46	92.46	92.46	92.46
Product changeover	26.94	60.61	19.17	28.72	128.94	104.92	57.71
Scheduling & production preparation	0.46	4.04	0.51	0.26	6.24	4.43	1.93
Raw material receiving & handling	18.92	161.95	14.64	10.96	277.26	47.53	88.41
Product shipment	6.82	27.62	5.83	4.85	435.30	24.80	11.38
Customer service	2.86	23.49	3.33	1.63	39.83	17.19	12.81
Total	174.63	404.27	160.26	172.62	1029.52	343.95	309.90

Comparison to Traditional Cost Accounting

It was of interest to compare the ABC results to the traditional cost accounting (TCA) system that was currently employed at AIRCO. Their current costing system allocated overhead costs strictly on a volume basis using direct labor hours as the single cost driver. Similar to the ABC development process, the first step is to compute the TCA overhead rate, which was calculated by dividing the total overhead cost ($4,458,605) by the total number of direct labor hours (370,924), which resulted in a

TABLE 9. ABC Final Results

Output parameter	Product						
	5-ton	6-ton	7.5-ton	10-ton	12.5-ton	15-ton	20-ton
Direct labor cost ($)	342.20	342.20	342.20	410.64	410.64	410.64	410.64
Direct material cost ($)	665	665	665	1957	1957	2510	2510
Overhead costs ($)	174.63	404.27	160.26	172.62	1029.52	343.95	309.90
Total product cost ($)	1181.83	1411.47	1167.46	2540.26	3397.16	3264.59	3230.54
Selling price ($)	1000	1300	1750	2560	3200	4572	5450
Profit %	−15%	−8%	50%	1%	−6%	40%	69%

TABLE 10. TCA Final Results

Output parameter	Product						
	5-ton	6-ton	7.5-ton	10-ton	12.5-ton	15-ton	20-ton
Direct labor cost ($)	342.20	342.20	342.20	410.64	410.64	410.64	410.64
Direct material cost ($)	665	665	665	1957	1957	2510	2510
Overhead costs ($)	240.41	240.41	240.41	288.49	288.49	288.49	288.49
Total product cost ($)	1247.61	1247.61	1247.61	2656.13	2656.13	3209.13	3209.13
Selling price ($)	1000	1300	1750	2560	3200	4572	5450
Profit %	−20%	4%	40%	−4%	20%	42%	70%

TCA overhead rate of $12.02 per direct labor hour. The overhead cost for each product was computed by multiplying the TCA overhead rate by the number of direct labor hours required for each product unit. Similar to the ABC process, the final step in the TCA analysis was to compute the total product costs and profit/loss analysis for each product. The final TCA results are provided in Table 10.

Table 10 shows that the AIRCO's current TCA system claims that the 5-ton and 10-ton products are unprofitable at their current selling prices and the other five products are thought to be profitable. Table 11 contains a comparison of ABC and TCA profit/loss analyses.

The ABC system has provided additional and valuable product cost information and indicates that their products are not consuming overhead costs on a volume basis. AIRCO was encouraged to implement the ABC system and examine the production costs and selling prices of the 6-ton and 10-ton products as these products (once believed to be profitable) were found to be unprofitable. The ABC analysis also indicated that the 10-ton product is not unprofitable and can continue to be sold at its current selling price.

TABLE 11. ABC vs. TCA

Output parameter	Product						
	5-ton	6-ton	7.5-ton	10-ton	12.5-ton	15-ton	20-ton
TCA profit %	−20%	4%	40%	−4%	20%	42%	70%
ABC profit %	−15%	−8%	50%	1%	−6%	40%	69%
ABC-TCA ($)	−65.78	163.86	−80.15	−115.87	741.03	55.46	21.41

SUMMARY

An ABC system was successfully developed for AIRCO, a manufacturer of industrial air conditioner units. It was apparent from the ABC analysis that AIRCO products do not consume overhead costs on a volume basis as represented by their current TCA system and valuable overhead cost driver information was obtained. The ABC analysis showed that the majority of their overhead cost was incurred to support indirect labor activities. When appropriately allocated to activity-driven cost pools, AIRCO found that a tremendous proportion (55%) of their overhead expenditures was associated with material handling activities. AIRCO was encouraged to streamline their material handling processes by reducing raw material and part transport distances within the facility layout. AIRCO should conduct an economic analysis to determine the feasibility of implementing automatic material handling systems. Reduction of product changeovers through improved production scheduling and more efficient product shipping practices were also recommended. The ABC analysis indicated that three of their seven products are losing money at their current selling prices. AIRCO should investigate the market feasibility of increasing the selling prices of the 5-ton, 6-ton, and 12.5-ton units in conjunction with reducing the overhead resource consumption of these products.

While the development process required a significant investment of time and effort from AIRCO employees, it was determined that the development effort was worthwhile, as valuable process and product information was obtained. In general, the required effort to develop an ABC system is strongly dependent on the amount and quality of available data. In this ABC application, the use of estimation techniques, like the expense activity dependence matrix, reduced the development effort to an acceptable level. The current ABC overhead rates will be valid until a major process or product change occurs. The ABC overhead rates should be updated to reflect any major operational or administrative changes. For example, if AIRCO changes their material handling process, this will likely change their overhead cost generation. In addition, the addition or subtraction of a major product line may also dictate an update to the ABC system. The AIRCO ABC system was implemented in a spreadsheet, which was designed to facilitate efficient updating.

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REFERENCES

Cooper, R., "The rise of activity-based costing—Part one: What is an activity-based cost system?" *Journal of Cost Management*, Vol. 2, No. 2, 1988a, pp. 45–54.

Cooper, R., "The rise of activity-based costing—Part two: When do I need an activity-based cost system?" *Journal of Cost Management*, Vol. 2, No. 3, 1988b, pp. 41–48.

Cooper, R., "The rise of activity-based costing—Part three: How many cost drivers do you need and how do you select them?" *Journal of Cost Management*, Vol. 2, No. 4, 1989a, pp. 34–46.

Cooper, R., "The rise of activity-based costing—Part four: What do activity-based cost systems look like?" *Journal of Cost Management*, Vol. 3, No. 1, 1989b, pp. 38–49.

Cooper, R. and R.S. Kaplan, "How cost accounting distorts product costs," *Management Accounting*, Vol. 69, No. 10, 1988a, pp. 20–27.

Cooper, R. and R.S. Kaplan, "Measure costs right: Make the right decisions," *Harvard Business Review*, Vol. 66, No. 5, 1988b, pp. 96–103.

Cooper, R., R.S. Kaplan, L.S. Maisel, E. Morrissey, and R.N. Oehn, *Implementing activity-based cost management: Moving from analysis to action*, Montvale, New Jersey: Institute of Management Accountants, 1992.

Johnson, H.T. and R.S. Kaplan, *Relevance lost: The rise and fall of management accounting*. Boston: Harvard Business School Press, 1987, p. 224.

Raz, T. and D. Elnathan, "Activity-based costing for projects," *International Journal of Project Management*, Vol. 17, No. 1, 1999, pp. 61–67.

Roztocki, N., J.F. Valenzuela, J.D. Porter, R.M. Monk, and K. LaScola Needy, "A procedure for smooth implementation of activity-based costing in small companies," *American Society of Engineering Management Conference Proceedings*, 1999, pp. 279–288.

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