VARIATION IN PRODUCTION VOLUME: THE IMPACT OF USING AN INTEGRATED ABC-AND-EVA SYSTEM TO REDUCE DISTORTIONS IN PRODUCT COSTS

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Abstract – **This paper examines the impact of variation in production volume on product cost, as estimated by three different costing systems. Production volumes were categorized as being small, medium or large. A Traditional (volume based) Cost Accounting System (TCA), an Activity-Based Costing System (ABC), and an Integrated Activity-Based Costing and Economic Value Added System (Integrated ABC-and-EVA) were compared. This comparison is illustrated using data from a field study performed at a small manufacturing plant which designed and produced precision custom injection-molds. During this field study, we developed and implemented the Integrated ABC-and-EVA System. Our results showed that when production volume varies substantially, the Integrated ABC-and-EVA System is more effective in reducing distortions in product cost than a TCA or standard ABC system.**

1. Introduction

Reliable cost analysis is a highly effective tool for strategic decision-making. Management, knowing that their costing system is yielding reliable cost estimates, is able to act decisively. There is less of a need to anticipate errors, or to make assumptions using a combination of guesswork and intuition. It is well known that efficient decisions are better made with hard data than with vague beliefs.

The Integrated ABC-and-EVA System is a costing and performance system which is able to yield reliable, complete, and up-to-date cost estimates. The Activity-Based Costing (ABC) component of this integrated system focuses on overhead (operating) cost, while the Economic Value Added component focuses on capital cost (Roztocki & Needy, 1999a; Roztocki & Needy, 1999b).

Most researchers agree that the integration of an ABC system and an Economic Value Added financial performance measure outperforms both traditional costing measures and the standard ABC, in terms of completeness and reliability of cost estimates (Hubbell, 1996a; Hubbell, 1996b; Roztocki & Needy, 1998; Cooper & Slagmulder, 1999). Still, there have been relatively few studies examining exactly when, and under what conditions, this integrated system helps to reduce distortions in product cost.

The main focus of this paper is, therefore, to examine the ability of the Integrated ABC-and-EVA System to reduce distortions in product cost when production volume varies substantially.

2. Methodology

In order to learn more about the distortion reduction ability of the Integrated ABC-and-EVA System when production varies in volume, a field study at a small manufacturing company was chosen as the main research methodology.

The field study was carried out in five major phases: business process analysis, system design, system implementation, data collection, and data analysis.

In the first phase, the manner in which the company conducted business was analyzed. In addition, company managers were familiarized with the Integrated ABC-and-EVA System and the efforts needed for its implementation. We made clear our expectations about what support, data, and input it would be necessary for them to provide.

In the second phase, an individually tailored Integrated ABC-and-EVA System was designed in cooperation with the managers.

In the third phase, the Integrated ABC-and-EVA System was implemented, alongside the existing Traditional Costing Accounting (TCA) system. During the this phase, the implementation procedure developed by researchers from the University of Pittsburgh and the State University of New York at New Paltz was used (Roztocki & Needy, 1999a; Roztocki, Valenzuela, Porter, Monk, & Needy, 1999; Roztocki & Needy, 1999b; Roztocki, 2000b). (For a more extensive explanation of the design and implementation procedure, interested readers may refer to the cited articles.)

In the fourth phase, data yielded by each costing system (TCA, standard ABC, and the Integrated ABC-and-EVA System) was collected over the course of approximately one fiscal year.

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Submitted to the 2000 American Society for Engineering Management (ASEM) National Conference.
ASEM National Conference Proceedings, pp. 341-346.

Finally, in the fifth phase, data collected during the field study was analyzed. This analysis took into consideration the common knowledge that factors such as diversity in production volume, product size, product complexity, material, or setup, often tend to distort cost information (Cooper, 1988). The main objective of our analysis was to focus specifically on the impact of variation in production volume on product cost estimates.

3. System Implementation

In this section, the implementation of a customized Integrated ABC-and-EVA System in a small manufacturing company is presented.

3.1 T&D Inc.

T&D Inc. (whose name has been changed to protect anonymity) is a manufacturer of precision custom injection molds in Pittsburgh, Pennsylvania. T&D was founded in 1957, and is owned and managed by two owner-managers, who bought the company in the early 1960s. T&D employs 30 people and claims to set the world's standard for the specification, design, and manufacture of precision injection-molds. All injection-molds are individually manufactured according to customer specifications. T&D's market is mainly regional. The company's business is highly competitive, and because high quality is a standard expected from all manufacturers engaged in this mature market, the primary criteria for long-term customer loyalty is price. 2/3rds of the company's revenue is generated by new molds, while the remaining 1/3 is generated through the repair of old molds. The market for new injection-molds is highly competitive, and T&D sales people often have difficulty obtaining desired sales prices for new molds.

In T&D's traditional cost accounting calculation, overhead was allocated to jobs based on their consumption of direct labor hours. The management of T&D believed that the cost information provided by the TCA system was unreliable, and sometimes lead them to poor decisions. Moreover, they felt that an accurate costing system was essential to their survival and the ability to remain competitive.

3.2 Data Collection

After the implementation of the Integrated ABC-and-EVA System, T&D's management provided us with all the necessary information for cost calculation, such as bill amounts, direct labor hours, engineering hours, and shipping fees. Based on this data, we calculated on-going product costs for T&D's incoming jobs. The results of our calculations were compared with the managers' own, on a weekly basis. We concluded our data collection phase after 30 new injection-molds were completed. T&D's management assured us that all of these were "typical" jobs. In our analysis, we also included all repair jobs which were performed during this time. (We chose to examine exactly 30 new jobs for two reasons: the time necessary for completion of these jobs and the duration of our data collection coincided, and 30 was a mathematically manageable number, close to the actual number, which was 32.) Over the course of the study, T&D used approximately 30,000 direct labor hours. Exhibit 1 summarizes actual bill amounts and information about direct labor consumption.

Exhibit 1. Bill Amount (in thousands of dollars) and Direct Labor Hours

Job	Bill Amount	Direct Labor Hours
Repairs	980.0	7,080
1	2.0	18
2	2.8	27
3	3.5	33
4	3.5	39
5	3.8	41
6	4.7	48
7	5.6	55
8	7.1	68
9	7.5	71
10	7.8	83
11	12.5	114
12	13.9	147
13	26.5	242
14	29.5	295
15	39.5	371
16	55.1	512
17	69.5	659
18	69.9	714
19	89.5	886
20	95.5	928
21	95.5	1,030
22	105.0	1,179
23	110.5	1,298
24	135.1	1,675
25	149.5	1,763
26	159.5	1,810
27	164.5	1,926
28	164.5	2,167
29	169.9	2,209
30	178.8	2,512
1-30	1,982.5	22,920
Total	**2,962.5**	**30,000**

In measuring product cost and profitability, each of the new mold jobs were calculated separately, while all repair jobs were aggregated into one group. Because the focus of this paper is more on the findings of our analysis, than implementation procedures for the Integrated ABC-and-

EVA System, interested readers are once again referred to the cited publications (Roztocki & Needy, 1999a; Roztocki & Needy, 1999b; Roztocki, 2000b). For the same reason, the details and intermediate results of our calculations are not included.

Exhibit 2 summarizes the estimates of three costing systems (TCA, ABC and the Integrated ABC-and-EVA System). In this analysis, capital cost was only taken into account by the Integrated ABC-and-EVA System. The TCA and ABC systems ignored capital cost. All individual jobs were sorted according to their consumption of direct labor hours.

Exhibit 2. Product Cost Information (in thousands of dollars)

Job	TCA	ABC	ABC-and-EVA
Repairs	788.5	892.6	915.0
1	2.1	3.1	3.2
2	2.7	3.7	3.8
3	3.3	4.4	4.5
4	3.6	4.2	4.4
5	3.6	4.7	4.8
6	4.2	5.1	5.3
7	4.9	5.6	5.7
8	6.3	6.4	6.6
9	7.1	8.2	8.3
10	7.3	9.2	9.5
11	12.1	12.9	13.0
12	13.7	13.7	14.0
13	23.2	23.4	23.8
14	24.1	23.9	24.5
15	35.1	34.2	34.6
16	44.8	40.1	40.6
17	65.7	55.2	56.0
18	67.6	56.3	57.1
19	77.1	70.1	71.0
20	87.1	81.2	82.1
21	95.1	89.1	93.1
22	104.1	93.4	97.2
23	109.5	94.2	99.8
24	130.1	121.2	129.9
25	150.8	142.8	152.1
26	160.1	155.1	160.4
27	160.9	157.5	161.7
28	173.9	170.1	174.2
29	191.2	189.3	196.8
30	190.2	179.1	197.0
1-30	1,857.4	1,982.5	1,835.0
Total	**2,750.0**	**2,750.0**	**2,850.0**

4. Data Analysis

In order to investigate the potential impact of diversity in production volume (job size) as well as type of job (repairs vs. new molds) on cost information, all of T&D's jobs were divided into four categories: Repairs, Small Jobs, Medium Jobs, and Large Jobs. The Repairs category included 320 repair jobs. The remaining 30 jobs for building new molds were divided, depending on their consumption of direct labor hours, into three size categories.

In the Repairs category, each individual job required a relatively small amount of direct labor hours (22 hours each, on average). Average billing for jobs in this category was approximately $3,100.00. The second category, Small Jobs, consisted of 10 jobs in building new molds. The average job in this category consumed approximately 48 direct labor hours, with a billing of $4,800.00, on average. Finally, the third and fourth categories, Medium and Large Jobs, each consisted of 10 new mold jobs. The summary of direct labor consumption and billing amounts for each category is shown in Exhibit 3.

Exhibit 3. Job Categories

Job Type	# of Jobs	Direct Labor Hours		Bill Amount (in thousands of dollars)	
		Total	Avg.	Total	Avg.
Repairs	320	7,080	22.1	980.0	3.1
Small	10	483	48.3	48.3	4.8
Medium	10	4,868	486.8	501.4	50.1
Large	10	17,569	1,756.9	1,432.8	143.3
Total	**350**	**30,000**	**85.7**	**2,962.5**	**8.4**

After T&D's jobs were divided into these four categories, the product cost information and profitability figures obtained from the three costing systems were examined. Exhibit 4 depicts the product cost information for each job category.

Exhibit 4. Product Cost Information (in thousands of dollars)

Job Type	TCA	ABC	ABC-and-EVA
Repairs	788.5	892.6	915
Small	45.1	54.6	56.1
Medium	450.5	411	416.7
Large	1,465.9	1,391.8	1,462.2
Total	**2,750.0**	**2,750.0**	**2,850.0**

Varying estimates of product cost, resulting from differences in job size and costing systems, were present. Similar to a previously published field study of small manufacturer, the ABC system showed lower product cost

for medium and large jobs, compared to TCA (Needy, Bidanda, & Gulsen, 2000). Because our data collection approach took into account all jobs performed during a certain time period, rather than a sample, our findings were more consistent than the previous approach. For example, overall product cost was shown to be equal in both the ABC and TCA analysis. Further, our results were contrary to the earlier field study (Needy, Bidanda, & Gulsen, 2000), which showed, in general, lower product costs in the ABC analysis. Our ABC analysis showed that ABC cost estimates for small jobs and repairs were higher than TCA estimates.

The variations in product cost resulting from differences in job size were examined by measuring changes to the product cost after adding capital cost to the ABC calculated estimates. (For the Integrated ABC-and-EVA System, the overall product cost increased by a capital charge of $100,000.00. This capital charge represented T&D's total capital cost.) ABC was chosen to perform this analysis because ABC-calculated cost estimates are regarded as the closest to true product cost. Exhibit 5 presents the analysis.

Exhibit 5. Estimates of Product Cost (in thousands of dollars)

Job Type	ABC	ABC-and-EVA	Difference	
Repairs	892.6	915.0	+22.4	(+2.5%)
Small	54.6	56.1	+1.5	(+2.7%)
Medium	411.0	416.7	+5.7	(+1.4%)
Large	1,391.8	1,462.2	+70.4	(+5.1%)
Total	**2,750.0**	**2,850.0**	**+100.0**	**(+3.6%)**

After adding capital charges to the product cost yielded by ABC, the overall product cost for T&D increased by 3.6 percent. After we traced the capital cost, using the Integrated ABC-and-EVA System, the increase in product cost was, however, different for different job categories. The smallest increase (+1.4 percent) was registered in the Medium sized jobs category. On the other hand, the largest increase (+5.1 percent) was registered in the Large jobs category. After careful examination, T&D's management confirmed that the relatively high capital charge in this job category could be attributed to the relatively high capital investments needed for large, long-term jobs. In many cases, for example, materials needed to be purchased and labor had to be paid for long before payment could be received.

Based on the results, it can be also assumed that a 3.6 percent addition to ABC-estimated product cost across all jobs would lead to distortions in product cost. As a result, product cost for Small and Medium jobs, as well as Repairs, would be overestimated, while product cost for Large jobs would be underestimated.

It is necessary to remember that T&D experienced relatively low capital cost. Still, there were enough substantial differences in cost estimates to warrant concern about the reliability of the standard ABC system. Based on this observation, it can be assumed that a company with a high capital cost would notice even greater distortions in cost estimates. Therefore, it can be concluded that for many companies, the arbitrary allocation of capital cost may lead to distortions in product cost and poor managerial decision-making.

5. Results

This section presents the results of our profitability analysis, as well as the impact of our analysis on T&D's business strategy.

5.1 Profitability Analysis

T&D's management was especially interested in comparing the profitability for recently built new molds with recently completed repair jobs. The profitability figures provided by three costing systems provided different information, as shown in Exhibit 6.

Exhibit 6. Profitability Figures (in thousands of dollars)

Job Type	TCA	ABC	ABC-and-EVA
Repairs	191.5	87.4	65
Small	3.2	-6.3	-7.8
Medium	50.9	90.4	84.7
Large	-33.1	41	-29.4
Total	**212.5**	**212.5**	**112.5**

According to the analysis provided by the Integrated ABC-and-EVA System, the Repair jobs and Medium sized jobs (ranging from approximately 100 to 1000 direct labor hours) were, as a group, profitable. In contrast, Small and Large jobs turned out to be unprofitable.

T&D's management was surprised with the results of our analysis. After our explanation, they conceded to its correctness. In some cases, they confirmed that the results of our analysis were consistent with their suspicions. For example, before the implementation of the Integrated ABC-and-EVA System, T&D's management suspected that, in reality, small jobs were not profitable as the TCA system suggested. In their observations, small jobs often required the same dedication of overhead resources as medium and large jobs. Therefore, the overhead allocation for small jobs should be higher than TCA suggested.

In other cases, the results of the analysis contradicted their beliefs. T&D's management was surprised with the analysis results for large jobs. Large jobs were shown by TCA calculations to be, on average, unprofitable. Until our analysis, T&D's management believed that this lack of profitability was actually an error on the part of their obsolete TCA system, and that the large jobs, in reality,

were profitable. Therefore, T&D sales people simply disregarded the cost information provided by TCA and pushed to obtain more orders for large jobs.

In reality, the large jobs were not the source of profit T&D once believed. First, in order to attract customers for large orders, they often made over-proportional price reductions. Second, to perform these large jobs, it was necessary to spend lots of money before a payment was received from the customer. Third, as a large job was performed, many scarce T&D resources were dedicated to it. In many cases, T&D was not able to perform other jobs concurrently, which resulted in lost orders. Fourth, some of the large jobs were very complex; so complex, that they were too much for T&D's know-how or equipment to handle, and costly outsourcing was necessary. Fifth, managing large jobs was more difficult than managing smaller ones. T&D, for example, did not have a professional job scheduling system, so even a small variation in scheduling negatively impacted job completion time. Often, T&D had to pay costly overtime or outsource to meet due dates. In addition, large jobs represented a relatively high business risk for T&D. For example, if a customer was not able or willing to pay for a large job, financial difficulties were likely.

5.2 T&D's New Business Strategy

One year after our initial Integrated ABC-and-EVA System implementation, we revisited the T&D Company. During the interview, we learned that T&D is still using and highly satisfied with the Integrated ABC-and-EVA System. The system is mainly used for cost control, profit planning and preparation of quotes. In addition, we found out that the company is performing much better financially. T&D's revenues, and more important, economic profit, increased. When asked about the reason for this improvement, T&D's management explained that it was the direct result of their new business strategy, built around the cost estimates of the Integrated ABC-and-EVA System.

The biggest change in their business strategy was in their selective approach toward large jobs. T&D sales people were more cautious in accepting large jobs, and in all cases, they prepared higher quotes for them, to provide insurance against the higher cost and business risk associated with large jobs. In some cases, these higher quotes were not accepted, in others they were accepted reluctantly. T&D believed that some customers, unsatisfied with the relatively higher quotes for large jobs, were "shopping around." However, the accepted large jobs turned to be value creators and contributed to the better business performance of T&D.

Another business move resulting from the Integrated ABC-and-EVA System implementation was the price increase of repair jobs by a few percentage points. This increase was accepted by most customers. Only a few went to "cheaper competitors." One reason for T&D's customer loyalty may have been that most of the repairs were done on molds which had been build by T&D over the past 30 years. This assured T&D business advantages over its competitors.

The T&D sales people, who were more actively looking for medium sized jobs, were indeed able to obtain more orders for them. These medium sized jobs were more than able to fill the remaining production time left by large jobs.

Overall, during our interview, T&D's management confirmed its great satisfaction with the Integrated ABC-and-EVA System and its usefulness for the future. They viewed the Integrated ABC-and-EVA System as the most important factor in the success and better business performance of T&D.

6. **Conclusions**

Our field study found that when there is a significant variation in production volume, ABC may produce unreliable product cost information, especially when capital costs are not taken into account or are simply allocated and left un-traced. After considering capital cost, the full product cost for many large jobs was substantially higher than the standard ABC system suggested.

There are many further research opportunities related to our field study and to the Integrated ABC-and-EVA System. For our analysis, we classified jobs as being small, medium, or large, according to their consumption of direct labor. A future researcher may, for example, explore the ability of the System to provide reliable cost estimates, using different criteria for defining job size. Large jobs could be those which consume a significant amount of material, demand many engineering hours, or have a higher cost to the customer.

In addition, our analysis showed that, for T&D, a certain range of jobs tended to be more profitable on average: medium sized jobs. In other words, we showed that extremely small or extremely large jobs tended to be unprofitable for T&D. Therefore, a future study may develop a methodology for estimating the range of jobs which tend to be most profitable for a particular company.

In most cases, the benefits of using the Integrated ABC-and-EVA System outweigh the expense and effort needed for implementation. This system, in order to support a successful decision-making team, needs, however, the benefit of up-to-date cost information. Therefore, many companies may choose to use the Integrated ABC-and-EVA *Information* System (Roztocki, 2000a), which more effectively captures all fluctuation in direct, overhead, and capital costs, and provides more reliable, complete and up-to-date product cost estimates.

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Submitted to the 2000 American Society for Engineering Management (ASEM) National Conference.
ASEM National Conference Proceedings, pp. 341-346.