Articles

Management Accounting for Advanced Technological Environments

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Management accounting systems designed decades ago no longer provide timely, relevant information for companies in today's highly competitive environment. New operational control and performance measurement systems are recognizing the importance of direct measurements of quality, manufacturing lead times, flexibility, and customer responsiveness, as well as more accurate measures of the actual costs of consumed resources. Activity-based cost systems can assign the costs of indirect and support resources to the specific products and activities that benefit from these resources. Both operational control and activity-based systems represent new opportunities for improved managerial information in complex, technologically advanced environments.

During the first half of the 20th century, U.S. industrial enterprises prospered by exploiting the economies of scale from the captive U.S. domestic market, by their ready access to capital, and by the gains from vertical integration resulting from the excellent U.S. raw material base and its extensive transportation and communication networks. These companies continued to prosper after World War II by having virtually the only intact industrial base to supply products to the rest of the world. Post–World War II developments, however, reduced much of the domestic U.S. advantage from vertical integration, as bulk transportation gave even resource-poor countries low-cost access to all forms of raw materials, as global capital markets permitted funds to be deployed in countries very different from where they were raised, and as information networks enabled companies to manage global—not just domestic—design, production, and distribution facilities.

As domestic economy-of-scale factors diminished in importance, companies needed far more accurate information on their true sources of worldwide competitive advantage. Operations had to be made more efficient; new products exploiting technological advances had to be effectively designed, manufactured, and marketed; and companies' energies had to be focused on the products and services that produced the most value to customers. Yet the management accounting systems of companies failed to adapt to the challenges of this new, far more competitive environment (*1*). Delayed, overly aggregate, and frequently distorted information on operating performance and product profitability made it difficult for diversified organizations to understand the actions necessary to become effective and efficient producers. Economies-of-scale efficiencies were dissipated by diseconomies of scope (greater variety and proliferation of activities) as companies failed to receive accurate, timely signals on the costs of expanding and sustaining their diverse activities (*2*).

For example, electronic companies were unable to send accurate signals to product designers about the actual cost of manufacturing products with thousands of unique and specialized components. Overhead costs for purchasing and materials escalated with the need to sustain more than 100,000 different parts in inventory, and manufacturing efficiencies suffered with the problems of handling, assembling, and testing a huge number of different parts (*3*). The cost systems of companies that had introduced automation for efficient high volume led them to lose the profitable orders for products best configured to run on these machines and to win and accept unprofitable orders to produce low-volume simple products requiring long setup times (*4*). Manufacturing facilities, characterized by inflexible automation for high-volume assembly operations, were expected to handle proliferating lines of products that actually required general purpose equipment. Engineers found it difficult to justify financially investments in computer-integrated manufacturing (CIM) technology equipment that would facilitate the high-variety, low-volume product strategy attempted by many companies (*5*).

New Production Processes

Companies today are implementing processes and procedures that stress total quality control (TQC). Defects are measured in parts per million (ppm), and managers are expected to achieve continual reductions in their ppm defect rates. Also featured are just-in-time (JIT) procedures that attempt to keep work flowing continually without interruption; JIT processes are characterized by small batch, zero-defect production, continually reduced setup and changeover times, and elimination of intermediate (work in process) inventories. Companies able to implement TQC and JIT programs have enjoyed greatly reduced lead times for delivery of product to customers, lowered manufacturing costs, and, in general, enhanced customer responsiveness. Yet even these successful companies have found that gains from TQC and JIT are not recognized by their organizations' management accounting systems. For example, Table 1 shows the improvements realized over a 3-year period in a computer company's integrated circuit (IC) testing facility: huge reductions in defects, throughput times, inventory, and scrap (*6*). Yet the management accounting system recorded higher unit and hourly costs for the IC test facility (*6*) (Table 2). Because of the upward drift in unit testing costs, the company had, several years

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Table 1. Summary of IC test performance for 1986 to 1988 (*6*). Values for inventory and scrap, in thousands.

Year	Defects (ppm)	Through-put (days)	Schedule performance (%)	Inven-tory (units)	Scrap ($)
1986	1000	35	85	2000	600
1987	500	9	89	288	171
1988	270	3	99	120	74

Table 2. Financial summary of IC test department for 1986 to 1988 (*6*).

Year	Cost per IC tested ($)	Cost per labor-hour ($)
1986	0.50	50.00
1987	0.52	54.86
1988	0.55	101.64

ago, opened a new test facility in Singapore, a decision that was reversed only last year when the much more favorable economics of the U.S. facility was revealed by a special study (*6*).

Historical Roots

The intellectual roots of contemporary organizations' management accounting systems can be found in the scientific management movement period of 1880 to 1915 (*7*). The engineers of the scientific management movement attempted to standardize and simplify production processes to promote efficiency in the use of direct labor and direct materials. The accounting control procedures stressed adherence to the centrally determined standards. Extensive reports on the deviations of actual costs from the standards (called variances) were prepared monthly. Information collection and processing technologies were crude and expensive. Therefore, accounting procedures used data that were already being collected for other purposes: direct labor quantities as reported on payroll time cards and material usage information. The costs of indirect or overhead resources (such as machinery, supervisors, and support workers) were allocated to products based on already existing data: units produced, a product's direct labor content, or its processing time.

Such procedures for assigning indirect costs to products did not introduce great distortions at the time. Indirect costs were relatively low, and most companies did not have great product variety. Procedures that averaged indirect costs across a narrow range of products were probably reasonably accurate. In addition, efficient mass production companies found it relatively easy to earn excellent returns on their capital. Therefore, they had little need to fine tune their design, process, pricing, and mix decisions for individual products.

Many costs were not even assigned to products. Financial accounting rules required that costs such as marketing, distribution, service, interest on debt, research, and product development be expensed as they were incurred, without being allocated to the cost of individual products. Thus, the companies' management accounting systems allocated only factory costs to products and made no attempt to understand the relation between other corporate expenses (the general, selling, and administrative expenses) and individual products, product lines, and customers.

Another distortion arose from the apparent gains enjoyed from filling up the capacity of the factory with incremental or special orders or with increased variety of product designs and options. Product variants whose selling price exceeded short-run variable costs (again typically measured only by direct materials and direct labor) were considered desirable because they could absorb overhead costs and contribute to profits. The cost, however, of the added support resources needed to handle the proliferation of products, models, and options was not traced to these additional items. Rather, the costs of the additional support staff required were allocated across all products, based on their relative volume of production, not on the demands individual products made on the plant's indirect resources.

Recent Trends

During the high growth period after World War II, subtle changes occurred that made obsolescent virtually all of the assumptions underlying the design of companies' management accounting systems. Technological progress led to automated machinery replacing direct labor in many production processes. Furthermore, a much higher percentage of a company's labor force consisted of production support staff and of engineers and managers who produced and analyzed information, designed new products, modified the design or production processes of existing products, and provided marketing, sales, and service activities for the company's increasingly diverse product line and dispersed distribution channels. Because of cost system design decisions taken decades earlier, none of the costs of these personnel were traced accurately to the company's products and product lines.

Ironically, despite the growing distortions in their management accounting systems, U.S. managers increasingly began to run their companies "by the numbers." Annual budgeting processes emphasized performance in financial accounting terms—increased earnings per share and return on investment. The annual financial targets were further decomposed into monthly budgets, with monthly income and expense statements becoming the main instruments for motivation and control. Accounting staffs, burdened by the complexity of rapidly closing the books on worldwide operations each month, had few resources remaining to produce information relevant to the day-to-day operations of their organizations or to contemplate the growing distortions of the signals from their internal cost systems.

Few executives recognized the futility of using an income measure to evaluate the performance of their organizations for periods as brief as 22 working days. Success in the more competitive environment required companies to make extensive investments to develop new products, improve their production processes, train and reeducate their employees, introduce advanced technology, and establish worldwide marketing, distribution, and information systems. Yet managers still relied on a financial accounting income model that even annually, much less monthly, was incapable of valuing the outcomes from these investments. Thus, many companies were being run "by the numbers" just when the financial income "numbers" were becoming less relevant and less meaningful as measures of short-run company success.

The delayed, aggregate, and distorted signals emanating from companies' accounting systems had unfortunate consequences. Product costing systems that allocated costs based on direct labor content or machine processing speeds encouraged companies to commit industrial and manufacturing engineering resources to reduce labor content or speed up production processes. But overhead costs still were spread to products based on their direct labor or machine hour content. Companies failed to see how faster but less flexible machines led to longer setup times, higher levels of inventory, lower quality production, and decreased customer responsiveness. Also, the introduction of faster, less flexible production processes led to large support staffs to collect and analyze data, schedule production, and move, handle, and inspect the output from large production batches.

Today, companies are benefiting from the greatly increased capabilities and lowered cost of information processing technologies. In fact, the enormous gains in the performance to price ratio of information technologies would by themselves have made obsolete earlier decisions on the appropriate level of detail and timeliness in cost systems design.

Companies are just beginning to experiment with new approaches to management accounting systems design. But some innovative approaches have already emerged in two primary areas: (i) operational control and performance measurement systems and (ii) measuring product and activity costs.

Operational Control and Performance Measurement Systems

Ideally, a performance measurement system should provide timely, accurate feedback on the efficiency and effectiveness of operations. Existing systems, typically reporting monthly, are flawed in several respects. Relevant information is too aggregate and received too late for corrective actions to be taken, the information is distorted by unnecessary allocations, and excessive attention is devoted to financial measures at the expense of operating measures.

Timeliness is perhaps the most important criterion for a well-functioning operational control system. Companies that produce output continually would benefit from daily, hourly, or even batch by batch operating reports. The reports could summarize what was produced, how much was produced, the unit costs and actual quantities of variable input resources (materials, labor, energy, and machine time) used in production, and the quality or yield of the output. It would have been prohibitively expensive 75 years ago to provide such exquisite detail about operations, but today's information technology makes such measurement rather inexpensive. One chemical facility collects 40,000 observations on its processes and products every 2 hours (*8*). For processes such as this under computer control, the operational control system can use data already available from the production system to provide rapid, accurate summaries of operating performance.

The old cost accounting model, derived from the scientific management movement, stressed adherence to standards determined by industrial engineers. Unfavorable variances were highlighted for explanation and correction. The new management accounting model emphasizes not variance analysis against a static standard, but information to support continuous improvement in quality, yields, manufacturing process times, and efficiencies. Managers and workers, attempting to achieve continuous improvements in their operations, need information to detect problems quickly and to guide their experimentation and learning activities. Knowledge no longer exists centrally, to be imposed on local operations; improvements are suggested and made locally. The focus of the operational control system has shifted from adherence to centrally determined standards to providing timely, accurate, and relevant information for local learning and improvement activities.

Financial summaries of departmental spending or actual batch costs provide only partial indicators of the efficiency of operations. Innovative companies adopting TQC and JIT production are developing measures of quality (such as ppm defect rates and process yields) and throughput times (the time from arrival of raw materials at the warehouse until the product has been manufactured and is ready to be shipped to the customer). The throughput time for a product (or service) can be represented as processing time plus inspection time plus movement time plus waiting time. For many operations, processing time is less than 5% of throughput time; that is, for a total throughput time of 6 weeks (30 working days), only 1 to 2 days of actual processing time may be required. During the remaining time, the part or product is being inspected, moved around the factory, or simply waiting—in storage, on the factory floor, or just before or just after a processing operation. In an ideal JIT system, the throughput time for a part just equals its processing time (a goal that like zero defects may be unattainable but is the standard against which progress is measured). Some companies have started to measure manufacturing cycle effectiveness (MCE) to evaluate their attempts to eliminate waste or nonvalue-added time: MCE equals processing time divided by throughput time. As the MCE ratio gets closer to 1, the organization knows that the amount of time wasted moving, inspecting, reworking, and storing products has been decreasing. The MCE ratio emphasizes the importance of managing time and increasing customer responsiveness, not just the traditional accounting goal of reducing costs.

Overall operating performance of an organization now includes measures on actual versus budgeted production, product by product, and the percentage of delivery commitments met each period. Vendor performance is tracked by frequency of defects and on-time delivery percentages. Performance from the customer's perspective is measured by frequency of customer complaints, returns, and allowances, and warranty and field service expenses. Some companies conduct systematic surveys of their customers to compute customer satisfaction indexes. Each operating indicator provides useful information, not easily captured or summarized by financial information, to monitor how well the company is improving its operations.

In summary, operational control systems feature timely reports on actual operations, including the actual (not allocated) quantities and unit costs of resources consumed, plus a variety of nonfinancial indicators. Both financial and nonfinancial data are shown as trends, with the target for nonfinancial data being perfection: zero defects, 100% yields, 100% on-time delivery, and MCE ratio equal to 1. Each period the organization's operating performance should be improving, getting closer and closer to the ideal.

Measuring Product and Activity Costs

Measuring product and activity costs is the second primary objective of a management accounting system. Virtually all manufacturing companies today still use their inventory valuation system to measure product costs, a procedure that leads to substantial distortions and omissions. The following example provides an illustration of the sources of the distortions.

A division of a German electrical manufacturer formerly produced only a few standard motors in high volumes (*9*). Because of competition from East European manufacturers, whose labor rates were significantly lower, the company decided to also produce customized motors. Within 10 years, 48% of its orders were for a single motor, and 75% were for less than five motors, although the motors produced for these orders accounted for only 25% of total volume. The plant still produced high-volume orders: 2% of the orders were for more than 100 motors and these accounted for 44% of total output. The current plant, producing both customized and standard motors, requires many more tasks to be performed than the 1970s plant that produced only a few standard motors in high volumes. More people are now required to schedule machines; perform setups; inspect output after each setup; to schedule, receive, and inspect incoming materials and containers; to move, count, and value inventory; expedite orders; rework defective materials; design and implement engineering change orders; negotiate with vendors; issue purchase orders; and update and program the much larger computer-based information system.

With any traditional cost system, the higher overhead cost of the newer, more complex plant would be spread across all motors, standard and customized, in proportion to the unit volumes of each motor. Whether indirect costs are assigned based on direct labor-hours, machine-hours, material quantities, or units produced, a standard motor that is 10% of the plant's output receives about 10% of the plant's indirect costs. In contrast, a unique customized motor that represents only 0.01% of the plant's output has only 0.01% of the plant's indirect costs allocated to it, even though it required special design, purchasing, scheduling, handling, and order processing.

The strategic consequences from using such a cost system in the new environment could have been disastrous. The plant would further deemphasize standard motors and replace the lost volume with an expanded line of specialty products with unique features and options, and generally much smaller unit volumes. Quote prices, estimated from the reported costs, would not necessarily cover the cost of resources associated with designing, producing, and handling customized motors. As this trend continued, new demands would be created for overhead and support resources, raising costs even further.

In this case, a new cost system was designed that captured much better the economics of producing customized motors, so that the company could compete simultaneously in the standard and custom motor businesses. The system recognized that many indirect costs were caused not by the volume of production, but by the transactions associated with scheduling the production of a batch of product, designing a product, or handling an order for the product, costs that were independent of the number of motors actually produced (*10*).

Such cost systems, called activity-based cost (ABC) systems, assign more accurately the costs of an organization's activities to products and product lines (*11*). The ABC systems are designed by first identifying the activities performed by each support and operating department and then computing the unit costs of performing these activities. For example, a manufacturing engineering department could be engaged in two principal activities: maintaining and updating the production process for each product manufactured, and implementing engineering change notices (ECNs). The cost of the manufacturing engineering department is first split between these two activities on the basis of interviews with departmental supervisor and on other available relevant data. Then, the quantity of each type of activity—for example, the number of products being manufactured and the number of ECNs performed—would be determined. Dividing the total cost of each activity (the cost of performing ECNs) by the quantity of the activity performed (total number of ECNs) yields an estimated cost of performing an ECN.

Once the unit cost of all activities has been determined, support and indirect costs are assigned to products based on the number of activities performed for each individual product. To compute the cost of a customized motor, the company determines, in addition to the direct labor and material content, the number of purchase orders issued for this motor; the number of special components that were designed; the number of times materials were received, moved, and inspected for this order; the number of setups, the number of ECNs required, and any other activities performed for that order. The quantities of each of these activities would then be multiplied by their unit cost and summed together to obtain the total cost of support activities for the motor. A similar analysis would be performed for all the motors made in a period.

The new product cost numbers from the activity-based analysis are usually strikingly different from those reported by any traditional system. In the motor factory (*9*), the additional costs of special components and unique orders were only 7% of total manufacturing costs. But a motor produced in a lot size of one had 30 to 40% higher costs assigned to it than a single motor produced in a lot of more than 100 motors. Relieving standardized motors of the costs of special orders and components reduces their costs by 5 to 7%, an amount that is small but still significant for mature products sold in highly competitive, price-sensitive product markets. In other applications of ABC systems, the indirect costs of complex, specialty products have increased by factors ranging from 100 to 1000%.

Key Assumptions

Several key assumptions underlie the activity-based analysis. Primarily, ABC systems assume that almost all indirect and support costs are variable. Many indirect expenses (such as the total salaries paid to manufacturing engineers) will not vary month to month with changes in the volume and mix of monthly production; that is, they appear to be fixed costs. These costs, however, become variable each year during the budgeting cycle when the organization authorizes annual spending levels in each of its support department cost centers. If the production environment has become more complex because of a greater number of transactions (setups, inspections, material movements, process specifications, ECNs, and purchase orders), then eventually more support people and support resources have to be added to the organization. The ABC system estimates the demand for support resources as a function of the volume, mix, and complexity of products, and of characteristics of the current production processes.

Although the ABC system may be estimated on historic data, its real benefit is to predict the future consequences of actions taken by managers. The objective is not to get a more accurate allocation of costs, but to estimate a cost model of the organization, a model that enables managers to predict future costs when production processes and distribution channels are changed and new decisions on marketing variables and product design are made. The costs of support activities become visible so that improvements in processes—to reduce setup times, to improve material layouts, to focus the factory, or to reduce order processing costs—produce an immediate and direct benefit on product cost. The savings from reducing defects or achieving JIT production capabilities can be directly attributed to the products for which the improvements have been made.

Activity-based product costs signal when the marketing department may wish to raise prices on complex, specialty products and to lower prices on high-volume simple products, or when it may wish to emphasize a different set of products, to change the product mix, or to encourage customers to shift to similar but more profitable products. The ABC system does not make decisions. Any decision must be the consequence of knowing both market opportunities (the customers' demands and preferences) and cost structures. A cost system can only provide information on the costs, not the revenue consequences, from decisions.

The ABC system also provides incentives for product engineers to design for manufacturability: to design products with fewer and more common parts that are easier to fabricate and assemble. Traditional cost systems do not reward good product designs and do not penalize bad ones. They determine a new product's cost based on its direct material cost and its labor- and machine-time demands. The ABC system provides far more explicit guidance as to the design parameters that create demands on the organization's indirect and support resources, and therefore encourages product engineers to design products with fewer components and more common components so that their manufacture makes fewer demands on support resources.

The cost model, derived from an ABC analysis, can also be used in the organization's budgeting process. At present, support resources are typically budgeted from the previous year's base, plus or minus small changes. In contrast, with an ABC model, managers first forecast next year's product mix and production schedule. From these forecasts, the quantities of activities required to produce the product mix in the specified way are determined. Knowing the total quantity of each activity driver, combined with an updated unit cost estimate for performing each activity, enables managers to compute the budgets for all indirect and support departments on the basis of the quantity of work demanded from these support resources.

CIM Technology

The activity-based approach helps to explain why many companies find it difficult to justify financially the acquisition of CIM technologies. Diversified, full-line producers can approach the efficiencies of a focused producer only with effective use of powerful, information-intense design and manufacturing technologies (*12*).

Consider, however, the process by which the benefits from a CIM investment are evaluated. An engineer requests authorization to acquire the expensive CIM system to permit the efficient manufacture of the high product variety now in the plant. The general manager, before approving the request, asks the controller to document the high cost of producing the current diverse, complex product mix. The controller checks the cost sheets from the existing traditional system and finds that the low volume, specialty products are no more expensive to produce than the high volume, commodity-like products: custom motors cost the same as standard motors. Thus, the primary justification for acquiring flexible manufacturing technologies has been undermined by a system that failed to signal the actual cost presently being incurred to support a high-variety, low-volume manufacturing strategy. The ABC system provides a much more supportive environment for demonstrating the potential savings from CIM investments.

Life Cycle Accounting

Companies engaged in extensive product and process development should assign to individual products and product lines the cost of the technological resources being expended. Otherwise product and process improvement costs can appear in the general overhead pool and be allocated to all products, including those for which little development effort has been performed.

In general, R&D is split into two categories. The costs of maintaining and improving existing products and product lines are traced directly to the items benefiting from these efforts. In effect, part of the cost of being in those lines of business is having to continually upgrade product characteristics.

The costs for fundamentally new products and processes, the second category, should be isolated and charged to a project account. For financial statement and tax purposes, these costs are expensed at the time they occur. But unless the initial expenditures are captured in a project account, managers will be unable to compare the amount spent on each product and process development effort with the subsequent cash flow benefits when a new product is marketed or a new process installed. Some people want to know over how many years they should amortize these initial project expenditures so that they can create a financial accounting measure of periodic income. Much more meaningful, however, is knowing the profitability of a project over its useful life, not how to carve such project profitability up into quarterly and annual slices. Accumulating new product and process R&D expenses into a project account, and recording cash benefits in subsequent years, enables managers to assess the profitability of their resource allocation decisions without the necessity of an arbitrary amortization of initial project expense.

Conclusion

Traditional management accounting methods that were developed decades ago when product diversity was low, production processes were largely driven by direct labor, and information processing costs were high have not been adequate for today's technologically advanced and globally competitive environment. Managers are experimenting with new methods for measuring performance and for measuring the costs of their activities. None of the new approaches are particularly difficult to implement, especially relative to the complex products and production processes already being successfully introduced by many companies.

The management accounting innovations do require that operating and technical people interact actively with financial staff to ensure that the performance measures and activity analysis accurately reflect contemporary design, production, and support processes. The widespread integration of newly developed operational control and activity-based systems into a unified company-wide accounting system will also require a period of experimentation and learning, a period for accounting innovation that will rival the innovations of a century ago when procedures were developed to help manage newly formed mass-production enterprises.

REFERENCES AND NOTES

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13. I thank R. Cooper and H. T. Johnson for extensive discussions of the ideas in this article.