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New Systems for Measurement and Control

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ABSTRACT

Companies' attempts to adapt to today's technological capabilities and globally competitive environment have been greatly constrained by antiquated accounting systems. Improved management accounting systems can be designed:

1) for operational control, to motivate the learning and improvement activities for managers and employees, and to provide feedback on the efficiency of operating processes;
2) for activity–based costing, to calculate accurately the profitability of individual products and customers; and
3) for capital investment decisions, to guide decisions on acquiring advanced technological capabilities.

The paper summarizes recent advances in all three applications.

Major changes are occurring in the competitive environment and the operations technology of manufacturing and service organizations. Companies' attempts, however, to adapt to today's technological capabilities and globally competitive environment have been greatly constrained by antiquated accounting systems.[1] Poor accounting systems by themselves will not lead to organizational failure. Nor will excellent accounting systems assure success. But management accounting systems must be viewed as an integral part of the organization's response to battling back in today's competitive environment. Excellent systems are needed to provide the right goals for decentralized managers and employees, to provide feedback on the efficiency of operating processes, to evaluate the actual profitability of products and customers, and to guide decisions on effective capital investment.

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HISTORICAL ROOTS

The intellectual roots of contemporary organizations' management accounting systems[2] can be traced back to the scientific management movement period of 1880-1915[3]. The mechanical and industrial engineers of this time attempted to standardize and simplify production processes to promote efficiency in the use of labor and materials. Accountants built on the work of these engineers to develop standard costs for the use of direct labor and materials.

Information collection and processing technologies at the time were crude and expensive. Therefore, procedures to allocate indirect or overhead costs to products used information already being collected for other purposes: units produced, material usage, and the labor quantities reported on workers' payroll time cards. Such procedures for assigning indirect costs to products were fine for those times and did not introduce great distortions. First, indirect costs were relatively low, compared with direct labor and materials costs, so that their allocation did not have much influence on costs. Second, most companies did not have great product variety. Procedures that averaged indirect costs across a narrow range of products were likely to be reasonably accurate. And third, the companies were developing efficient mass production capabilities for a growing and prosperous market. They found it relatively easy to get excellent returns on their capital, and therefore had little need to fine tune design, process, pricing, and mix decisions for individual products.

During this period, capital investment decisions were guided by an accounting measure, Return on Investment, developed at the DuPont Corporation. This measure worked well at a time when most investments were in the form of physical capital, machinery, and facilities. For these investments, the prospective benefits of operating savings in labor and material usage were relatively easy to quantify.

A final influence on management accounting systems design was the necessity to value inventory for the external financial reports. Again, because of the rudimentary state of information technology, simple procedures had to be used to allocate periodic production costs between units sold and units still on hand (i.e., inventory). Also, financial accounting rules required that costs such as marketing, distribution, service, interest on debt, research, and product development be expensed as **period costs** rather than allocated to products. As a consequence, the management accounting systems allocated only factory or production costs to products and made no attempt to understand the relationship between other corporate expenses (the selling, administrative, and technology expenses) and individual products, product lines, customers and marketing channels.

In principle, companies could have run separate systems for financial and management accounting, so that the management accounting system could be optimized for internal decision-making and control, rather than be constrained by the rules for external reporting.[4] But because of the high cost of developing and running multiple systems, the low distortions for companies with narrow product lines and labor-intense production processes, and the minimal consequences, at that time, for decision-making and control with distorted product costs and aggregate, infrequent operating information, most companies chose to use one system for both financial reporting and management accounting.

RECENT TRENDS

During the high growth period following World War II, subtle changes occurred that undermined virtually all the assumptions underlying the design of companies' accounting systems. Automated machinery replaced direct labor in many production processes. A much higher percentage of a company's employees were used not to actually work on the products, but to support the production process, to handle the information necessary for effective management of complex, hierarchical organizations, to design products and the processes that produced them, and to provide marketing, sales, and service activities for the company's increasingly diverse product line and dispersed distribution channels. But because of cost system design decisions taken decades earlier, the management accounting system continued to stress direct labor efficiencies, and to measure product costs based on their direct labor content.[5] Timely information on the performance of the increasingly automated processes was not provided, and the expenses of the growing army of indirect, support, and managerial employees were not related to the activities they performed and the products and customers they supported.

CONSEQUENCES

The delayed, aggregate, and distorted signals emanating from companies' accounting systems had unfortunate consequences. Product costing systems, allocating operating expenses based on direct labor content or machine processing speeds, encouraged companies to expend resources on speeding up production processes. But the higher overhead costs still were spread to products based on their direct labor content. Companies failed to see how faster but less flexible machines led to longer set-up 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 or overhead staffs to collect and analyze data, schedule production, and move, handle and inspect the output from large production batches.

Companies attempted to reduce their costs by outsourcing to lower cost (frequently overseas) suppliers much of their internal production, particularly items with high direct labor content which the cost accounting system reported as expensive to produce internally. The added costs of a larger purchasing department to investigate and negotiate with external suppliers, and of the additional staff that scheduled deliveries, received and inspected incoming items, and moved purchased items into and, subsequently, out of inventory were spread to the products still being fabricated within the shop. Also, the costs of poor quality from apparently low-cost suppliers, the higher inventory levels, longer logistics pipelines, higher obsolescence and diminished customer responsiveness were invisible in the calculations and measurements.

Apparent accounting gains were generated by filling up the capacity of the factory with incremental or special orders, or with increased variety of product designs and options. The increased workload in the factory made it possible to report good performance along traditional efficiency measures, such as labor and machine utilization ratios. The special orders and products also helped to "absorb overhead." Any excess of selling price above short-run variable costs (again typically measured only by direct materials and direct labor) was felt to be a bonus; available to cover 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 for the far more diverse plant 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.

Capital investments for new technology, especially technology offering the possibilities for radical improvements in manufacturing processes proved difficult to justify. The benefits from higher quality, new product capabilities, reduce changeover times, and greater flexibility were not easily quantified. Thus, new investments stressed shorter-term projects whose benefits were easy to identify, such as bottleneck relief projects and simple capital for labor (automation) substitutions.

Companies following the erroneous signals from their management accounting systems became vulnerable to more focused competitors, particularly overseas competitors, who chose to emphasize better product designs for manufacturability, higher quality products and production, faster throughput, and more rapid customer responsiveness. As U.S. domestic economy of scale factors diminished in importance, companies needed far more accurate information on their true sources of worldwide competitive advantage. Yet their aggregate and distorted accounting information made it virtually impossible for large, vertically-integrated or diversified product organizations to understand either their underlying sources of profitability or the actions necessary to become more efficient producers of products and services. Thus, economies of scale were dissipated by diseconomies of scope (higher variety and proliferation of activities) as companies failed to receive accurate, timely signals on the costs of expanding and sustaining their diverse activities.

PROSPECTS FOR REFORM

Fortunately, as companies now contemplate the design and implementation of a new generation of accounting systems, they are benefiting from the greatly increased capabilities and lowered cost of information processing technologies. Companies are just beginning to experiment with new approaches to accounting systems design. But some innovative approaches to management accounting systems design have already emerged.[6] At present, we can identify innovation opportunities in three areas:

1. Operational Control and Performance Measurement Systems
2. Activity-Based Strategic Profitability Measurement Systems
3. Capital Investment Decisions

OPERATIONAL CONTROL AND PERFORMANCE MEASUREMENT SYSTEMS

An effective operational control and performance measurement system should provide timely, accurate feedback on the efficiency and effectiveness of operations. Existing systems are flawed in several respects: relevant information is received too late for corrective actions to be taken, the information is reported at too aggregated a level, 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. For companies that produce output continually, it would be most helpful to have daily, hourly, or even batch by batch operating reports. The reports could summarize what was produced, how much was produced, the quantities and costs of variable input resources used in production (materials, labor, energy, machine time), and the quality or yield of the output.[7] Attempting to improve production processes with present systems, that provide only monthly summaries of operations, are akin to training a bowler by providing feedback and information only after one month of throwing balls at pins, and then only reporting the aggregate number of pins knocked down during this period (e.g., 27,562), how this number compares to budget, and how it compares to the number knocked down during the same month a year ago. The information may be accurate (and auditable) but it does little to improve this bowler's performance.

Seventy-five years ago, it would have been prohibitively expensive to provide continual detail about operations. But today's information technology makes such measurement rather inexpensive. For operations under computer control, the data already exist to run the process. The operational control system need only build on the existing production systems to collect, summarize, and report the relevant data. Reports do not have to be printed on paper; they can be made available to managers on video screens and their results summarized periodically for higher management review.

Operational control information will be most helpful to motivate and evaluate the continual improvement activities of employees. The old cost accounting model, derived from the scientific management movement, stressed adherence to previously determined standards. Unfavorable variances were highlighted for explanation and correction. The focus of new operational control systems must shift from adherence to centrally determined standards to providing timely, accurate, and relevant information that will enable operators to detect problems quickly and to guide their experimentation and learning activities. And this feedback should emphasize not performance against a static standard, developed by industrial engineers from study of existing internal processes, but ongoing improvement from previous levels. Meeting historically-determined standards is not sufficient in a competitive world. The new model emphasizes continual improvements in quality, yields, throughput times, on-time delivery and efficiencies.[8]

The standard for performance has become perfection: zero defects, 100% yields, zero scrap, 100% on-time delivery, and no waste in throughput times or processing. The data on current actual performance should be displayed graphically so that progress towards getting closer to the ideal can be readily observed. If benchmarks short of ideal operations are desired, then the standards should be set based on the performance of the company's best worldwide competitor. But this can only be a short-run objective, since by the time the company achieves this performance level, its best competitor will be well beyond that performance.

The second important design criterion for the operational control system is accuracy. Only if the quantities of resources consumed and products produced are accurately measured can employees and managers receive useful feedback on their operating performance. If accurate measures exist of the quantity of a resource consumed by an operating department, because of metering or detailed reporting, then the cost of that resource can be assigned to operating managers and made part of their periodic operating report. But if the actual resource quantities used by individual operating departments are not known, the aggregate expense should not be allocated to operating managers. No useful control or performance measurement purpose is served by contaminating a short-run performance report with allocated indirect or common costs. Periodic, perhaps weekly, summaries of operating expenses incurred by a department are useful but these departmental expense reports should not be burdened by allocated costs.

The third design characteristic of an effective operational control system is to include, in addition to any financial summaries provided, a relevant variety of non-financial indicators. Financial summaries of departmental spending or actual batch costs provide only partial indicators of the efficiency of operations. Companies attempting to improve the quality of their manufacturing processes can benefit from continual measurements of process yields, defect rates, scrap and rework rates, and first-pass yields – the percentage of items completed without any rework required.

As companies strive to achieve just-in-time operations, they will want to monitor their performance in reducing total throughput time. The throughput time for a product (or service) can be represented as:

$$\underset{\text{Time}}{\text{Throughput}} = \underset{\text{Time}}{\text{Processing}} + \underset{\text{Time}}{\text{Inspection}} + \underset{\text{Time}}{\text{Movement}} + \underset{\text{Time}}{\text{Waiting / Storage}}$$

For many operations, processing time is less than 5 percent of throughput time; that is, for a total throughput time of six weeks (30 working days), only one to two 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 until the next operation can be scheduled, the machine set-up, and the part fixtured into place. 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 still worth striving for). A key measure, the Manufacturing Cycle Effectiveness (MCE), captures the current state of an organization's attempts to eliminate waste or non-value-added time:

$$\text{MCE} = \frac{\text{Processing Time}}{\text{Throughput Time}}$$

As the MCE Ratio gets closer to 1, the organization knows that the amount of time wasted moving, inspecting, and storing products has been decreasing. The MCE Ratio emphasizes the importance of managing **time** and increasing responsiveness to customers, not just the traditional cost accounting goal of managing costs. Other measures to support a JIT philosophy include average set-up times, distance traveled by products in the factory, and average days production in inventory.

In summary, operational control systems should feature timely reports on actual operations, including the actual (not allocated) quantities and unit costs of resources consumed, plus a variety of non-financial indicators to monitor the continual improvement activities of operating managers. All the data, financial and non-financial, should be shown as trends, with the target for non-financial data being perfection or, in the short-run, the performance of the company's best worldwide competitor. Each period the organization's operating performance should be improving, getting closer and closer to the ideal.

ACTIVITY-BASED STRATEGIC PROFITABILITY MEASUREMENT SYSTEMS

Virtually all manufacturing companies use their inventory valuation system to measure product costs. As discussed earlier, this system, in today's environment of large indirect expenses and product diversity, produces highly distorted product costs. Service companies, who have not had to assign expenses to their products for financial statement purposes, have operated for decades without knowing product costs. They collected costs in functional or responsibility categories but made little effort to assign accurately their operating expenses to their products and customers.

Product cost distortions occur in virtually all organizations producing and selling multiple products. An example provides a simple illustration of the sources of the distortion. Consider two factories, both making pens using identical capital equipment and physical facilities. Plant I is a focused producer that manufactures only blue pens, 1,000,000 units per year. Plant II is a full line producer. In addition to producing blue pens, (100,000 per year), it produces a variety of other colors: 100,000 black, 50,000 red, 20,000 green and so on. Plant II also produces a wide variety of specialty colors (such as 800 purple pens per year), plus pens that write on a variety of surfaces (flip charts, transparencies, white boards, etc.) All together, Plant II, like Plant I, produces 1,000,000 pens per year, but with several thousand different color, packaging, and writing surface combinations.

Despite the similarity in product, physical facilities, and total output of the two plants, a visitor walking through them would notice dramatic differences. Plant II contains many more people: to schedule machines, perform setups, inspect output after each setup, to schedule, receive and inspect incoming materials and packages, 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. Plant II also operates with much higher levels of idle time, overtime, inventory, rework, and scrap.

Any traditional cost system will assign about 10% of Plant II's overhead cost to blue pens. Whether indirect costs are assigned based on direct labor-hours, machine-hours, material quantities, or units produced, blue pens represent 10% of the plant's volume of activity and will, therefore, receive 10% of the plant's indirect costs. Similarly, a low volume product such as the 800 purple pens produced each year would have .08% (800 divided by 1,000,000) of the plant's indirect costs assigned to it. If a blue and a purple pen had the same labor times, machine processing times, and direct material costs, then the standard cost of the two products would be **identical** under any traditional cost system.

The strategic consequences from using such a cost system can be disastrous. Over time, the market price for blue pens, and for most high-volume standard products, will be determined by focused and efficient producers like Plant I. Managers of Plant II will find it difficult to compete in the blue pen market because their reported profit margins in these lines will be low or even negative. The managers of Plant II will look for profit growth in their new product lines – designer colors, specialized writing surfaces – where they earn attractive price premiums, perhaps 10 to 20 percent. They will de-emphasize standard, commodity-like products where the plant seems uncompetitive, and shift to an expanded line of specialty products with unique features and options, and generally much smaller unit volumes. Of course, scaling back on blue pens and proliferating the product line to replace the lost volume will create new demands for overhead and support resources, raising costs even further.

New management accounting systems can be designed that will capture much better the economics of Plant II to reveal that blue pens have much lower unit expenses than purple pens. Basically, as the comparison with Plant I shows, many of an organization's indirect costs are caused not by the volume of production, but by the transactions associated with scheduling the production of a batch of product, regardless of the volume produced in the batch.[9]

Activity-based cost (ABC) systems represent a new approach for measuring the consumption of indirect resources by products and customers.[10] ABC systems are designed by first identifying the activities performed by each support and operating department and then computing the unit cost of performing these activities. For example, the activities of a materials handling department could be identified as moving incoming materials from the receiving dock into inventory (proportional to the number of incoming shipments), moving materials from inventory to machines (proportional to the number of setups), and moving finished goods into the packaging and shipping area (proportional to the number of shipments made in a period). Based on interviews and observation, the total cost of the materials handling department would be assigned to the three main activities it performs, counts made of the quantity of each type of activity performed in a period, and the cost divided by the quantity to obtain the unit cost of each activity.

Once the unit costs of all activities have been determined, we can accurately assign support and indirect costs to products based on the number of activities performed for each individual product. The expenses assigned to individual products with the activity-based analysis are usually strikingly different from those reported by any traditional system. The assigned indirect expenses of relatively simple, high volume, mature products (such as blue pens) generally declines by amounts ranging up to 5 and 15%, not a huge amount, but significant for mature products sold in highly competitive, price sensitive product markets. The indirect expenses assigned to complex, specialty products, especially those produced in quite small batches (like purple pens) can increase, however, by factors ranging from 100% to 1,000%.

When the expenses of support activities are traced directly to products, improvements in production processes – to reduce setup times, to improve material layouts, to focus the factory, or to reduce order processing costs – produces an immediate and direct reduction in costs assigned to products. Any savings produced by continual improvement efforts to reduce defects or achieve just-in-time production capabilities can be directly attributed to the products where the improvements have been made.

The ABC analysis also helps to explain the widely observed phenomenon that overhead increases when production volume expands but tends to remain fixed when volume contracts. Volume usually expands by adding new product models and features that create a demand for additional overhead resources to handle the increased diversity and complexity of operations. When volume contracts, however, it does so across the board and the company must still support its full product line. Therefore, diversity and complexity remain constant even as volume contracts, causing the demand for many overhead resources to remain constant. Companies who have tried to reduce their overhead costs, by across the board spending cuts, but who have not eliminated the cause or demand for overhead, have found that they eventually must restore the overhead resources recently eliminated in order to cope with the complexity of operations that has remained in the factory.

Selling, General, and Administrative Expenses

The ABC analysis should not be limited to production support expenses. Many companies have selling, general, and administrative expenses (SG&A) that exceed 20% of total revenues. For financial and tax accounting purposes, most if not all these costs are expensed each period rather than treated as product-related costs; these costs are considered below the [gross margin] line expenses, not part of the cost of sales. Yet these costs must also be traced to the activities – product and customer related – that create the demand for the SG&A resources.

Selling and marketing expenses are usually collected in several categories: commissions, advertising, promotion, warranty, technical support, catalogs, and so on. For each category, managers need to understand which customers, distribution channels, products, or product-lines receive the benefits from or generate the demands for the resources. Typically, selling and marketing expenses are allocated based on relative sales dollars but, other than for sales commissions, it would be unusual for any marketing expense category to be driven solely by sales dollars. For certain customers, sales are made on low gross margin because the company knows that no advertising, promotion, technical support, or catalogs are required to reach them. Other channels or classes of customers require large quantities of these marketing resources. Allocating SG&A expenses proportional to sales revenue biases the profitability of the first type of customer downward and artificially reports higher profits for the second class of customers, potentially leading to poor decisions on supporting, opening, or closing alternative distribution channels. Working capital – inventory and accounts receivable – can also be assigned so that accurate return on investment calculations can be made for individual product lines, customers and channels.[11]

For marketing decisions, the more accurate ABC product costs can identify a very different set of winners and losers. Traditional cost systems create an incentive for companies to proliferate their product line and marketing channels. When overhead costs are spread based on production or sales volume, and when most overhead costs are thought to be "fixed", then almost any new product or customer will appear attractive by contributing to covering the "fixed" overhead. Even when a customer fails to achieve its expected level of sales, the customer is not abandoned. After all, revenues are still being generated and the traditional cost system will likely signal that the sales are still profitable, especially on a contribution margin basis. Inevitably, steady growth occurs in the diversity of product offerings and customers served.

In contrast, the activity-based assignment of indirect expenses signal when the marketing department may wish to raise prices on complex, specialty products and lower prices on high-volume simple products, or when it may wish to change the product mix to more profitable products and customers. A Swedish wire company, Kanthal, performed a profitability analysis on its domestic customers and discovered that only 30 percent of these were profitable; 40 percent were breakeven and 30 percent were unprofitable. Salespersons, educated in the findings from the analysis, were able through pricing changes and influencing customers' buying behavior to transform unprofitable customers into profitable ones.[12]

Product Design

The ABC system also provides incentives for product engineers to design products with fewer and more common parts, and to use existing vendors where feasible. While much discussion has occurred about **design for manufacturability**, traditional cost systems do not reward good product designs, nor penalize bad ones. They determine a new product's cost based on its direct material cost and its labor- and machine-time demands. Electronics companies, such as Tektronix and Hewlett-Packard, found themselves supporting products requiring that more than 100,000 different components be stocked and available. These companies modified their cost system so that material-related overhead would be applied based on the number of different part numbers. This procedure signaled that materials overhead was driven more by the variety of different parts stocked than by the physical volume of parts consumed.[13] The ABC system provided far more explicit guidance as to the design parameters that create demands on the organization's indirect and support resources, and therefore encouraged product engineers to design products that made minimal demands on these indirect resources.

Life-Cycle Accounting

Research and development expenses require special treatment. Companies engaged in major product development and process improvements should attribute the costs of design and engineering resources to the products and product lines that benefit from them. Otherwise product and process improvement costs will be shifted onto product lines for which little development effort has been performed.

In general, R&D can be split into two categories. First, the costs of maintaining and improving existing products and product-lines should be traced to those items that will benefit from these efforts. In effect, part of the cost of being in those lines of business is the necessity to continually upgrade characteristics.

The second category represents R&D costs for fundamentally new products and processes. These costs can be isolated and charged to a project account. For financial statement and tax purposes, the costs will be expensed as incurred. But managers should 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. Unless the initial expenditures are captured in a project account, they become almost impossible to reconstruct when a subsequent analysis may be attempted. Some people want to know over how many years they should amortize these initial project expenditures. This viewpoint reflects a financial accounting mentality to always attempt to measure periodic income. Much more meaningful is knowing the profitability of a project over its useful life, not how to carve such project profitability up into little quarterly and annual slices. Accumulating new product and process R&D expenses into a project account, and recording cash benefits in subsequent years, will enable managers to assess the profitability of their resource allocation decisions without the necessity of an arbitrary amortization of initial project expense.

Summary of Activity-Based Strategic Profitability Measurement

Understanding which products, customers, and markets are making or losing money for the company is vital for focusing managements' attention. A wide array of strategic options become available to managers for increasing their organization's profitability once they have an accurate picture of how revenues earned relate to expenses incurred. But attempting to formulate strategies on product design, pricing, product mix, customers, marketing channels, and production processes, based on the information from traditional cost accounting systems, is like attempting to land at a busy airport in a dense fog, with inaccurate instruments. The pilot, under the circumstances, will do the best he can but the results are likely to be disastrous.

CAPITAL BUDGETING DECISIONS

Almost all companies today have formal, quantitative procedures for evaluating and authorizing expenditures for major, capital investments. During the first half of the 20th century, measures such as payback period and the accounting return on investment (average accounting income divided by average book value of investment) dominated the capital investment evaluation process. Since the 1950s, sophisticated discounted cash flow analytic techniques that specifically incorporated the time value of money have been used to evaluate proposed investment projects. Despite the prevalence of formal procedures to guide investment decisions, U.S. companies still found themselves in the 1980s with poor manufacturing capabilities and technologies when compared with many of their Asian and European competitors.

Several factors, no one of them likely dominant, help to explain the poor investment decisions by U.S. corporations. Some of the reasons are technical in nature, relating to poor implementation of the theory of investment justification.[14] Companies have used hurdle or discount rates in excess of 20%, even though extensive studies of capital markets indicate that after-tax returns of between 10 and 13% provide adequate compensation to the firm's long-term suppliers of capital. Another error arises when a discount rate of, say 13%, is used – a rate that incorporates an expected inflation rate of about 5% – yet no provisions for higher future selling prices and for the benefits from higher future cost savings on labor, materials, and energy are incorporated into the analysis. Also, risk is factored into the analytic procedure by arbitrarily raising the discount rate – a technique that systematically biases investment against projects with long-term benefits and payouts – rather than analyzing the risk through a careful scenario and simulation analysis.

These technical flaws are relatively easy to solve, once they have been detected in organizations. More problematic is whether companies can go beyond their formal, quantitative analysis to incorporate vital technological and strategic considerations. Accounting and finance staffs take comfort in the apparent precision of their quantitative estimates, and become uncomfortable incorporating the more subjective, difficult-to-quantify returns from proposed investment decisions.[15]

One obvious error occurs when managers develop the base case or "do-nothing" alternative. Invariably, analysts predict that even without adopting a new technology investment they will enjoy a continuation of the status-quo – today's selling prices and market share – into the future. Evidence from a large number of industries has revealed that companies that do not maintain their technological leadership will, in the future, have to absorb lower market share or lower pricing margins, and frequently both. Thus, the correct base-line forecast for the status-quo alternative of rejecting new technology investments will be some annual percentage decline in net cash flows in the future years. Henry Ford said, "If you need a machine and don't buy it, you pay for it without getting it."

Related to the error of ignoring the consequences from becoming a technological laggard is ignoring the cost of delay. The discounted cash flow procedure makes investment delay look like an attractive alternative; the investment outlays made in the future seem less expensive than those made today because tomorrow's dollars are worth less. Omitted from this calculation, however, is the cost of catching up once competitors have made their investment decisions, gained experience with the new technology, and begun to offer better products and services to their (and our) customers. As with estimating the time path of decline from failing to invest, we do not have precise estimates of the cost of technological delay. But the cost of losing first mover advantages is not zero, especially in an environment where product life cycles are short and an ability to rapidly deliver new products to customers has become critical.

Many new technology investments enable a company to have dramatically improved production processes leading to much higher quality and reliability of products, improved and more reliable product delivery times, and reduced new product launch times. Some new technologies affect the kind and number of products that can be produced because of improved tolerances, ease of design changes, and rapid introduction of new product designs into production. While some of these benefits can be quantified into financial terms, others are much more difficult to estimate. Additional factors even more difficult to quantify financially include the organizational learning that occurs when new technology is successfully introduced, and the option that the company has acquired to be a major participant in any new technological advances that might occur. Companies that postpone, defer, or reject entirely new technology possibilities do not create the learning opportunities for their employees and organization; nor do they become literate enough to enjoy subsequent, but currently unanticipated, technological advances.

At present, discounted cash flow techniques emphasize precise financial estimates of investment outlays and labor savings but omit subjective estimates of the benefits from improved quality, customer responsiveness, and technological literacy. Consequently, many procedures ignore the strategic, non-financial considerations entirely; in effect assigning a precise (but arbitrary) zero value to these considerations. Thus investments are biased towards projects where increased output or labor savings for existing products are easy to document – short-term bottleneck relief projects, and simple capital-labor substitutions. Investments are biased against strategic long-term projects where the principal benefits involve developing entirely new processing and product capabilities and promoting organizational learning.

Is Financial Justification a Constraint on Capital Acquisition?

Senior executives frequently deny that any strategic investment, especially one that was needed to keep the company at the leading edge of technological capabilities, was ever rejected because its projected financial return failed to clear a targeted hurdle rate. They can cite instances where significant investments were made without even looking at a discounted cash flow or rate of return calculation. This viewpoint, however, overlooks how systems of capital investment authorization – with stringent payback and hurdle rates – can prevent many new project ideas from ever reaching senior managers. Undocumented and unknown are the many projects that senior managers have never seen because potential sponsors felt the projects fell short of the company's financial criteria.

Thus senior managers may be correct in their claim that no strategic investment they had the opportunity to review was ever rejected on narrow financial grounds. But the complaints of manufacturing engineers and operations managers, that many new technology investments cannot pass the corporate financial criteria, are likely also valid.

Systematic manufacturing technology investments are most likely to be made when they support the strategic goals of the firm. Investments in process technology that reduce total cycle time, that provide a capability to customize products, that meet stringent process requirements demanded by new products, or that shorten the introduction process for new products emphasize the achievement of such strategic capabilities. Thus, investments in advanced process technology depends on the priority senior management places on strategic manufacturing capabilities. Companies whose competitive strategy emphasizes the use of state-of-the-art manufacturing technologies, will devote greater resources and maintain higher and more consistent levels of manufacturing investment than will companies with other strategic values. Such commitments to strategic technology tend to get made almost independent of prevailing interest rates. The lag in U.S. investment for manufacturing technology has likely been caused not by a high cost of capital but by senior company executives' lack of commitment to manufacturing capability for achieving competitive success.

CIM Technology

Perhaps the most radical new technology investment of all is computer-integrated-manufacturing (CIM). CIM investments are radical and disruptive because they cannot be adopted by isolated units. They require complete system integration among marketing, design, production, and finance. And many of the potential benefits do not occur unless a completely integrated system is successfully installed. Thus, a sequence of local incremental automation decisions – the traditional approach to adopting new technology – will leave the organization with capabilities below that of a global, integrated CIM facility.

Yet another barrier impedes the authorization of CIM investments. A diversified, full-time producer, like the Plant II pen factory described in the activity-based cost system section, that attempts to approach the efficiencies of a focused producer, such as Plant I making only blue pens, will require highly effective use of powerful, information-intense design and manufacturing technologies.[16]

Consider the process by which the benefits from a CIM investment are evaluated. A manufacturing engineer in Plant II explains in the Capital Authorization Request how the expensive CIM investment will permit the low cost 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 and finds that the low volume, specialty products are no more expensive to produce than the high volume, commodity-like products; the 800 purple pens have the same unit costs as the 100,000 blue pens produced each year. Thus, the primary justification for acquiring flexible manufacturing technologies has been undermined by a cost system that fails to signal the actual cost presently being incurred to support a high-variety, low volume manufacturing strategy. Activity-based cost systems, apart from their value for strategic profitability analysis, also highlight the high costs, using traditional manufacturing processes, of a customized, high product variety strategy. The ABC systems provide a sounder and more supportive environment for demonstrating the potential savings from CIM investments.

A CALL TO ACTION

Managers need to experiment with new methods for measuring performance, for better matching the costs and revenues from their activities, and for authorizing expenditures for new technological capabilities. Traditional methods developed decades ago, when product diversity was low, production processes were largely driven by direct labor, and information processing costs were high are no longer adequate for today's advanced technological environment. Newly designed management accounting systems can produce more accurate, more timely, and more relevant information to support the decision, investment, and learning activities necessary for success in globally competitive markets.

None of the procedures described in this paper is particularly difficult to implement, especially given the enormous capabilities and low cost of information technology. Data from production control systems, from systems that run and monitor production processes, and from information systems used for order entry, engineering design, and sales and marketing can be captured and used in management accounting systems. Sophisticated relational data bases and languages permit transactions to be entered only once but to be used in a wide variety of applications with little additional cost. In order to keep the systems relevant for current strategies and technologies, the systems must be subject to ongoing review and adaptation so that the performance being measured and evaluated is consistent with overall corporate objectives. Most important, senior operating and financial managers must recognize the critical role that good measurement systems can play in achieving organizational objectives. They must acknowledge the limitations of systems designed decades ago for a manufacturing era that no longer exists. Once this recognition and acknowledgement has occurred, the opportunities for designing improved systems will not be difficult to pursue.

FOOTNOTES

[1]Robert S. Kaplan, "Accounting Lag: The Obsolescence of Cost Accounting Systems," in *The Uneasy Alliance: Managing the Productivity-Technology Dilemma*, Kim B. Clark, Robert H. Hayes, and Christopher Lorenz, ed., (Boston: Harvard Business School Press, 1985), pp. 195-226.

[2]We distinguish between financial and management accounting systems. Management accounting systems collect, process, and report information for internal managerial decision and control activities. Financial accounting systems prepare aggregate financial statements for external constituencies such as stockholders, investors, regulators, and tax authorities.

[3]See Chapter 3, "Efficiency, Profit, and Scientific Management" in H. Thomas Johnson and Robert S. Kaplan, *Relevance Lost: The Rise and Fall of Management Accounting*, (Boston: Harvard Business School Press, 1987), pp. 47–59.

[4]In fact, companies in German-speaking countries typically run two separate systems, one each for financial and management accounting.

[5]One Swedish executive described his need for a new cost system, "In our previous system, cost were either manufacturing costs that were allocated to products based on direct labor, or they were Selling and Administrative Costs, that were treated as period expenses and were unanalyzed. This treatment may have been correct 100 years ago when we had one bookkeeper for every ten blacksmiths, but today we have eight bookkeepers for every three blacksmiths. This means that most of our costs today are indirect and our previous system didn't know how to allocate them." (Kanthal (A), HBS Case #9-190-002).

[6]Financial accounting innovation has been more difficult because of statutory constraints imposed by the SEC, FASB and the IRS. Therefore, new financial accounting developments must await the findings and conclusions from the management accounting initiatives currently underway.

[7]For an example of such a system, see Robert S. Kaplan, "Texas Eastman Company," (HBS Case #9-190-039).

[8]Analog Devices has instituted a company-wide measurement system to emphasize continual improvement in its operations; see Ray Stata, "Organizational Learning – The Key to Management Innovation," *Sloan Management Review* (Spring 1989), pp. 63–74.

[9]Jeffrey Miller and Thomas Vollman, "The Hidden Factory," *Harvard Business Review* (September–October 1985), p. 142; Robin Cooper, "Cost Classification in Unit-Based and Activity-Based Manufacturing Cost Systems," *Journal of Cost Management* (Fall 1990), pp. 4–140.

[10]Examples of Activity-based cost systems appear in Robin Cooper, "Schrader Bellows," Harvard Business School Case Services, #9-186-272, and Robert S. Kaplan, "John Deere Component Works (A)," Harvard Business School Case Services, #9-187-107. See also Robin Cooper and Robert S. Kaplan, "Measure Costs Right: Make the Right Decisions," *Harvard Business Review* (September–October 1988).

[11]See Robin Cooper and Robert S. Kaplan, "Winchell Lighting (A) and (B)," HBS Case #9-187-074 and -075 for an example of a company that assigns marketing and distribution expenses more accurately to channels. Also, Thomas S. Dudick "Why SG&A Doesn't Work," *Harvard Business Review* (January–February 1987) pp. 30–37.

[12]See Robert S. Kaplan, "Kanthal (A) and (B)," HBS Cases 9-190-002 and -003.

[13]See Robin Cooper and Peter Turney, "Tektronix: Portable Instruments Division (A)," HBS Case 9-188-142, and "Hewlett Packard-Roseville Networks Division," HBS Case 9-189-117.

[14]These issues are discussed in Robert S. Kaplan, "Must CIM be justified by faith alone?" *Harvard Business Review* (March–April 1986).

[15]These strategic issues have been articulated in "Thinking Long Term: The Capital Investment Process," Chapter 3 of Robert H. Hayes, Steven C. Wheelwright, and Kim B. Clark, *Dynamic Manufacturing: Creating the Learning Organization*, (New York: The Free Press, 1988); see also Kaplan, "Must CIM be justified by faith alone?".

[16]The ability of CIM to enable efficient production of high-variety, low-volume items has been discussed in Joel Goldbar and Marian Jelinek, "Plan for economies of scope," *Harvard Business Review* (November–December 1983), pp. 141–148; and R. Jaikumar, "Post-industrial Manufacturing," *Harvard Business Review* (November–December 1986), pp. 69–76.