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Measuring Customer, Internal Business Process, and Employee Performance

In Chapter 8, we introduced the Balanced Scorecard, a system of measuring performance across four integrated and linked perspectives: financial, customer, internal business processes, and learning and growth. In Chapters 9 and 10, we discussed financial performance measurement, including return on investment and economic value added. In this chapter, we explore measurements in the other three Balanced Scorecard perspectives.

CUSTOMER PERSPECTIVE

As noted in Chapter 8, the customer perspective encompasses several generic measures of the successful outcomes of a well-formulated, well-targeted strategy. These generic customer measures typically include:

- Market share
- Account share
- Retention and loyalty
- Acquisition
- Satisfaction
- Profitability

We discuss each in turn.

Market and Account Share

Market share reflects the proportion of business in a given market that a business unit sells. Market share can be measured in terms of number of customers, dollars spent, or unit volume sold. This measure, especially for targeted customer segments, reveals how

well a company is penetrating a desired market. For example, a company may temporarily be meeting sales growth objectives by retaining customers in nontargeted segments but not increasing its share in targeted segments. The measure of market share with targeted customers would balance a pure financial signal (sales) to indicate whether an intended strategy is yielding expected results.

When companies have targeted particular customers or market segments, they can also use a second market share–type measure: the account share of those customers' business (some analysts refer to this as the share of the "customers' wallet"). The overall market share measure, calculated as the volume of business done with targeted customers, could be affected by the total amount of business those customers are offering in a given period. That is, the share of business with the targeted customers could be decreasing because the customers are offering less business to all their suppliers. Companies can measure for each customer and for each segment how much of the customer's and market segment's business they are receiving. Such a measure provides a strong focus to the company when trying to dominate its targeted customers' purchases of products or services in categories that it offers.

Customer Retention

Customer retention and loyalty can be measured by the rate at which a business unit retains or maintains ongoing relationships with its customers. Clearly, a desirable way for maintaining or increasing market share in targeted customer segments is to retain existing customers in those segments. The insights from research on customer loyalty and the service profit chain[1] have demonstrated the importance of **customer retention.** Many companies can readily identify all of their customers; such companies include, for example, industrial companies, distributors and wholesalers, newspaper and magazine publishers, computer on-line service companies, banks, credit card companies, and long-distance telephone suppliers. These companies can readily measure customer retention from period to period. Beyond just retaining customers, many companies will wish to measure customer loyalty by the percentage growth of business with existing customers.

Customer Acquisition

Customer acquisition can be measured by the rate at which a business unit attracts or wins new customers and business. Companies seeking to grow their business will generally have an objective to increase their customer base in targeted segments. Customer acquisition could be measured by either the number of new customers or the total sales to new customers in the targeted segments. Many companies solicit new customers through broad, often expensive, marketing efforts. Examples include companies in the credit and charge card business, magazine subscriptions, cellular telephone service, cable television, and banking and other financial services. These companies can examine the number of customer responses to solicitations and the conversion rate—number of actual new customers divided by number of prospective inquiries. They can measure solicitation cost per new customer acquired and the ratio of new customer revenues per sales call or per dollar of solicitation expense.

Customer Satisfaction

Both customer retention and customer acquisition are measures of outcomes; they indicate whether the company has been successful in meeting customers' needs. A measure of customer satisfaction provides a *leading* indicator of these outcomes; it is a feedback measure on how well the company is doing, at least with existing customers. Recent research has indicated that just scoring adequately on customer satisfaction is not sufficient for achieving high degrees of loyalty, retention, and profitability. Only when customers rate their buying experience as *completely* or *extremely* satisfied can the company count on their repeat purchasing behavior.[2]

Customer satisfaction measures do have some limitations. They assess attitudes, not actual behavior. Therefore satisfaction measures should not be the only customer-based measure used by an organization. Satisfaction measures will work best when they are used to indicate the critical factors necessary to generate repeat and new business. Customer satisfaction measures should be coupled with more-objective outcome measures of behavior such as customer retention and new customer acquisition.

Customer Profitability

Success in the core customer measures of share, retention, acquisition, and satisfaction, however, does not guarantee strategic success. Obviously, one way to have extremely satisfied customers (and angry competitors) is to sell products with many features and services at very low prices. Because customer satisfaction and high market share are themselves only a means of achieving higher financial returns, companies will probably wish to measure not just the extent of business they do with customers but also the profitability of that business, particularly in targeted customer segments. This measure couples the Balanced Scorecard perspective with the activity-based cost approach described in Chapters 4 and 5, which permits companies to measure individual and aggregate **customer profitability.** Companies should want more than satisfied and happy customers; they should want profitable customers. A financial measure, such as customer profitability, helps to keep customer-focused organizations from becoming customer-obsessed.[3]

The customer profitability measure may reveal that certain targeted customers are unprofitable. Newly acquired customers are particularly likely to be unprofitable because the considerable sales effort to acquire a new customer has yet to be offset from the margins earned by selling multiple products and services. In these cases, lifetime profitability becomes the basis for deciding whether to retain or discourage currently unprofitable customers.[4] Newly acquired but unprofitable customers can still be valued because of their growth potential. But unprofitable customers who have been with the company for many years will likely require explicit action to cope with their incurred losses.

Beyond the Core: Meeting Customer's Expectations

Once a company identifies its targeted customers, managers must determine what will cause these customers to purchase a product or service from the company. These factors will drive success with the core customer outcome measurements of satisfaction, acquisition, retention, and market and account share. For example, customers could value short lead times and on-time delivery. Or they could value a constant stream of innovative

products and services. Or they could value a supplier able to anticipate their needs and capable of developing new products and approaches to satisfy those emerging needs. As noted in Chapter 8, these attributes are organized into three categories:

- Product/service attributes
- Customer relationship
- Image and reputation

Individual companies have developed their own ways of measuring attributes along these three dimensions, as a function of their strategy and their targeted customer segments.[5] In virtually all Balanced Scorecards, however, three dimensions stand out as particularly important: time, quality, and price. We discuss here representative measures that companies can use to develop time, quality, and price metrics for enhancing performance for targeted customers.

Time

Time has become a major competitive weapon in today's competition. Being able to respond rapidly and reliably to a customer's request often is the critical skill for obtaining and retaining valuable customers' business. For example, Hertz's #1 Card enables busy travelers to walk off their arriving flight and go directly to their rented car, where the completed paper work has previously been placed, the trunk opened for luggage, and the car already air-conditioned in summer or heated in winter. Banks accelerate approval of mortgage and loan applications, reducing waiting times from weeks to minutes. Japanese auto manufacturers can deliver a newly ordered customized car to a consumer's driveway in less time (one week) than it takes the purchaser to obtain a valid parking sticker from government authorities for the vehicle. Companies competing on the time dimension can measure customer lead times, the time from when the customer initiates a request for a product or service until the time when the product or service has been delivered. Such a measure signals the importance of achieving and continually reducing lead times for meeting targeted customers' expectations.

Other customers may be more concerned with the reliability of lead times than with just obtaining the shortest lead times. For example, many shippers still prefer to use trucks rather than rail but not because trucks are cheaper or even faster for long-distance moves. Most railroads still cannot deliver reliably within the specified one day (or less) receiving window demanded by the customer, so many shippers (and their customers) would rather take a more expensive, even longer, transport medium that can guarantee arrival within a desired time interval. Such reliability is especially important for manufacturers who operate without inventories under a just-in-time discipline. Those companies want deliveries to their assembly plants to arrive within a one-hour time window. A late delivery will shut down an entire production facility that operates with zero inventories of raw materials and purchased parts. For service companies, think about the frustration of a consumer who has taken time off from work to be at home but then has to wait for hours because a promised delivery or installation is not made at the scheduled time or is not made at all. If reliable delivery is vital for important customer segments, then a measure of on-time delivery (OTD) will be a useful performance driver for customer satisfaction and retention.

The OTD measure should be based on the customer's expectations. Telling Honda or Toyota that your definition of "on-time" is ± 1 day, when their production process can

tolerate a delivery window no wider than ±1 hour, will not likely win you much business from these demanding companies.

Lead time is important not only for existing products and services. Some customers value suppliers who can offer a continual stream of new products and services. For such market segments, a short lead time for introducing new products and services could be a valued performance driver for customer satisfaction. This objective could be measured as the elapsed time from when a new customer demand has been identified to the time when the new product or service has been delivered to the customer. We will talk more about this time-to-market measure when discussing metrics for the innovation process.

Quality

Quality was a critical competitive dimension during the 1980s and remains important to this day. By the mid-1990s, however, quality had shifted from a strategic advantage to a competitive necessity. Many organizations that could not reliably deliver defect-free products or services ceased to be serious competitors. Because of all the attention devoted to improving quality during the past 15 years, it may now offer limited opportunities for competitive advantage. It has become a hygiene factor; customers take for granted that their suppliers will execute according to product and service specifications. Nevertheless, for certain industries, regions, or market segments, excellent quality may still offer opportunities for companies to distinguish themselves from their competitors. In this case, customer-perceived quality measures would be highly appropriate to include in the Balanced Scorecard's customer perspective.

Quality measures for manufactured goods could be measured by incidence of defects, say parts-per-million (PPM) defect rates, as measured by customers. Motorola's famed 6σ program strives to reduce defects to fewer than 10 PPM. Frequently, third-party evaluations provide feedback on quality. The J.D. Power organization provides information and rankings on defects and perceived quality in automobiles and airlines. The Department of Transportation provides information on each airline's frequency of late arrivals and lost baggage incidents.

Other readily available quality measures include returns by customers, warranty claims, and field service requests. Service companies have a particular problem not faced by manufacturers. When a manufacturer's product or piece of equipment fails to work or satisfy the customer, the customer will usually return the product or call the company asking for repairs to be made. In contrast, when a quality failure occurs from a service company, the customer has nothing to return and usually no one responsive to complain to. The customer's response is to cease patronizing the service organization. The service organization may eventually note a decline in business and market share, but such a signal is delayed and, by that time, almost impossible to reverse. The organization will typically not even know the identity of customers who tried the service, were poorly treated, and then decided never to use that organization's services again. For this reason, several service organizations offer service guarantees.[6] This offer, to immediately refund not only the purchase price but generally a premium above the purchase price, provides several valuable benefits to the company. First, it allows them to retain a customer who otherwise might be lost forever. Second, it receives a signal about the incidence of defective service, enabling them to initiate a program of corrective action. And, finally, knowledge of the existence of the service guarantee provides

strong motivation and incentives for the people delivering customer service to avoid defects that would trigger a request for the service guarantee. Companies with service guarantee programs can use the incidence and cost of service guarantees as a customer-based quality measure.

Quality can also refer to performance along the time dimension. The on-time delivery (OTD) measure, previously discussed, is actually a measure of the quality of the company's performance in achieving its promised delivery date.

Price

With all the emphasis on time responsiveness and quality, one might wonder whether customers still care about price. One can be assured that whether a business unit is following a low-cost or a differentiated strategy, customers will always be concerned with the price they are paying for the product or service. In market segments in which price is a major influence on the purchasing decision, units can track their net selling price (after discounts and allowances) with those of competitors. If the product or service is sold after a competitive bidding process, the percentage of bids won, especially in targeted segments, will provide an indication of the unit's price competitiveness.

Even price-sensitive customers, however, may favor suppliers who offer not low prices but low costs to acquire and use the product or service. At first glance, one may think we are playing with semantics by distinguishing between low price and low cost, but real and important differences exist between them. Take a manufacturing company that is sourcing a key purchased part from a supplier. The low-price supplier may turn out to be an extremely high-cost supplier. The low-price supplier may deliver only in large quantities, thereby requiring extensive storage space and receiving and handling resources plus the cost of capital associated with buying and paying for the parts well in advance of when they are used. The low-price supplier may also not be a certified supplier; that is, the quality of the parts received may not be guaranteed to conform to the buyer's specifications. Therefore, the buying company has to inspect the incoming items, return those found to be defective, and arrange for replacement parts to arrive (which themselves have to be inspected). The low-price supplier may also not have a stellar on-time delivery capability. In that case, its failure to deliver reliably at scheduled times would make it necessary for the buying company to order well in advance of need and to hold protective stock in case delivery was not as expected. Late deliveries cause higher costs for expediting orders and rescheduling the plant around the missing items. And low-price suppliers may not be electronically connected to their customers, thereby imposing higher costs on customers when they order and pay for the purchased parts.

In contrast, a low-cost supplier may have a slightly higher purchase price but also the ability to deliver defect-free products, directly to the workstation, just in time, as they are needed. The low-cost supplier also enables customers to order and pay electronically. The buying company incurs virtually no costs for ordering, receiving, inspecting, storing, handling, expediting, rescheduling, reworking, and paying for parts purchased from this low-cost supplier. Some companies allow certain suppliers to replace their purchasing function, not taking ownership of parts until they are released, just-in-time, directly to a workstation. Suppliers should strive to organize their production and business processes so that they can be their customers' lowest-cost supplier. They may choose to compete along the cost (to the customer) dimension, not just by offering low prices and discounts.

Such a measure requires that the suppliers set an objective to minimize their customers' total costs for acquiring parts from them.

Companies in several industries have the opportunity to do even better than to become their customers' lowest-cost supplier. If the customer is an organization that resells purchased items to its own customers and consumers—such as a distributor, wholesaler, or retailer—the supplier can strive to become its customers' **most profitable** supplier. Using activity-based costing techniques, the supplier can work with its customers to build an ABC model that enables the customer to calculate the profitability by supplier. For example, Maplehurst, a frozen bakery goods company, works directly with its customers—in-store bakeries in supermarkets—to calculate profitability by different classes of products: purchased bread, cakes, and muffins, in-store prepared goods, and in-store-heated frozen bakery products (Maplehurst's product line). Maplehurst has been able to demonstrate to customers that the frozen (and subsequently in-store-heated) goods are among the most profitable in the product line, a discovery that invariably leads to increased business for Maplehurst.

The current battle between national-brand beverages, such as Coca-Cola and Pepsi-Cola, versus retail-brand private labels, such as Presidents' Choice and Safeway Select, is being fought on both sides by calculations for the retail grocery store to determine which products are more profitable for the store to stock and sell. The calculation is more complex than the traditional gross margin (net selling price less purchase price) used by most distributors, wholesalers, and retailers to calculate their profitability by product line or supplier. For example, the national-brand beverage companies deliver their product directly to the store and use their delivery people to stock the product on the shelves. The retail-brand beverage companies deliver their product to warehouses and require the store resources for receiving, handling, storing, delivery, and merchandising. But the national brands also tend to occupy some of the most visible and valuable space in the stores, whereas the retail-brand products occupy normal shelf space. So care must be taken to correctly and fully account for all costs when comparing the profitability of alternative suppliers.

The benefits, to the excellent supplier, from a customer's profitability calculation are enormous. What more powerful message can a company deliver to its customers than a demonstration that it is the most profitable supplier the customer has? Thus, companies supplying customers who stock and resell their products or services can drive customer satisfaction, loyalty, and retention by measuring the customers' profitability and striving to become a highly profitable supplier. Of course, the supplier must also balance this measure by calculating its own profitability of supplying each of its customers. Decreasing its own profitability to increase its customers' may lead to satisfied and loyal customers but not happy shareholders and bankers.

INTERNAL BUSINESS PERSPECTIVE: OPERATIONS AND INNOVATION PROCESSES

Once a company has identified the critical factors required to attract, retain, and satisfy targeted customers, it can specify measures for the critical internal processes at which it must excel to deliver performance along the identified factors. As discussed in Chapter 8, companies typically have to be excellent at both the "long-wave" of value creation in their innovation process and the "short-wave" operating process. We start by focusing on oper-

ational excellence, characterized by performance measures of time, quality, and cost of internal operating processes.

Operational Excellence: Time, Quality, and Cost Measurements

Process Time Measurement

The value proposition being delivered to targeted customers often includes short response times as a critical performance attribute. Many customers strongly value short lead times, measured as the time elapsed from when they place an order until the time when they receive the desired product or service. They also value reliable lead times, as measured by on-time delivery. Manufacturing companies generally have two ways of offering short and reliable lead times to customers. One way is to have efficient, reliable, defect-free, short-cycle order fulfillment and production processes that can respond rapidly to customer orders. The other way is to produce and hold large stocks of inventory of all products so that any customer request can be met by shipments from existing finished goods inventory. The first way enables the company to be a low-cost and timely supplier. The second way usually leads to very high production, inventory carrying, and obsolescence costs, as well as to an inability to respond quickly to orders for nonstocked items (because the manufacturing processes are typically busy building inventories for normally stocked items). Because many manufacturing companies are attempting to shift from the second way of satisfying customer orders (producing large batches for just-in-case inventory) to the first way (producing small orders, just in time), reducing cycle or throughput times of internal processes becomes a critical internal process objective.

Cycle, or throughput, times can be measured many different ways. The start of the cycle can correspond to the time the:

1. Customer order is received
2. Customer order, or production batch, is scheduled
3. Raw materials are ordered for the order or production batch
4. Raw materials are received
5. Production on the order or batch is initiated

Similarly, the end of the cycle can correspond to the time the:

1. Production of the order or the batch has been completed
2. Order or batch is in finished goods inventory, available to be shipped
3. Order is shipped
4. Order is received by the customer

The choice of starting and ending points is determined by the scope of the operating process for which cycle time reductions are being sought. The broadest definition, corresponding to an order fulfillment cycle, would start the cycle with receipt of a customer order and would stop when the customer has received the order. A much narrower definition, aimed at improving the flow of physical material within a factory, could correspond to the time between when a batch is started into production and when the batch has been fully processed. Whatever definition is used, the organization would continually measure cycle times and set targets for employees to reduce total cycle times.

In many factories, processing time is less than 5 or 10% of throughput (or cycle) time; that is, for a total throughput time of one month (22 working days), less than eight hours of actual processing time may actually be required. During the remaining time, the part is waiting, either in storage or on the factory floor, or just before or just after a processing operation, until the next operation can be scheduled and the part fixtured into place. In an ideal JIT system, the throughput time for a part exactly equals its processing time. While this goal, just like zero defects, may be unattainable, it sets a target by which progress can be measured.

To motivate employees to achieve JIT operating processes, several organizations use a metric, manufacturing cycle effectiveness (MCE), defined as:

$$\text{MCE} = \frac{\text{processing time}}{\text{throughput time}}$$

This ratio is less than 1 because:

$$\text{Throughput time} = \text{processing time} + \text{inspection time} + \text{movement time} + \text{waiting/storage time}$$

The Japanese manufacturers who had led the way in devising and implementing JIT systems emphasize the importance of reducing throughput time by rewriting the above equation as

$$\text{Throughput time} = \text{value-added time} + \text{non-value-added time}$$

where *value-added time* equals processing time (the times during which work is actually being performed on the product); and *non-value-added time* represents the time the part is waiting, being moved, or being inspected. Many Japanese manufacturers also refer to the non-value-added time as *waste time* to highlight that no value is being created for the customer when the product is not being processed. The time has been wasted by inefficiencies in the manufacturing process.

Poor and uncertain quality are prime sources of delays. Time required to inspect parts, rework parts, replace a scrapped part by starting a new item into production, or wait for a machine breakdown to be repaired all contribute to lengthening throughput times. Thus, as a firm reduces its incidence of in-process failures, it can also reduce its production throughput time.

Perhaps the major source of delays in conventional manufacturing processes is producing quantities of products in excess of current demand. The traditional rationale for such excess production is the need to economize on setup and ordering costs. In effect, the existence of large setup and ordering costs makes small lot sizes uneconomical. Conventional wisdom in U.S. businesses and universities led managers to attempt to optimize lot sizes through the use of mathematical models. Engineers and operations analysts computed economic order quantities (EOQs) that seemingly provided an optimal balance among setup or ordering costs, storage and holding costs, and stockout costs. Needless to say, this treatment understated considerably the cost of creating inventory. Also, the large EOQ lot sizes led to substantial throughput delays—first to complete the batch production run and then to move it into storage until the subsequent processing operation could be freed up to handle the large batch of work.

The approach of attempting to optimize lot sizes was similar in philosophy to the erroneous search for the optimal number of defects in order to minimize manufacturing costs. Leading manufacturers no longer believe that a tradeoff exists between total manufacturing costs and defect rates, so they are now striving to continually reduce PPM (parts-per-million) defect rates. Analogously, many of these same companies are attempting to drive their setup times to zero.

Reliance on the EOQ formula had a further and more subtle insidious effect on production processes. Because people believed that the economics of lot sizes and setups had been well handled by the EOQ formula, little attention was paid to the time spent on setups or whether production orders were being completed on time. Toward the end of the month, when productions and sales quotas had to be met, or when an important customer complained bitterly about a delayed shipment, production specialists—called expediters—were empowered to "hot wire" a production order through completion, overriding the "scientifically" computed production plan.

The just-in-time philosophy takes a more dynamic view of how to optimize production. The EOQ formula accepted existing setup or ordering costs as given, and it attempted to choose lot sizes that were optimal with respect to those parameters. With the JIT approach, lot size is not optimized; it is minimized by attempting to drive setup times to zero. In JIT, inventory is viewed as a form of waste, a cause of delays, and a signal of production inefficiencies (in that mounds of inventory are created to buffer production stages from one another).

Applying Process Time Measurements in Service Industries

Just-in-time production processes and the manufacturing cycle effectiveness (MCE) ratio were developed for manufacturing operations, but they are just as applicable to service companies. If anything, eliminating waste time in a service delivery process is even more important than in manufacturing companies, because consumers are increasingly intolerant of being forced to wait in line for service delivery.

Take an example from the banking industry. Many of us are familiar with the process of gaining approval for a mortgage application on a house that we wish to purchase. The process starts by showing up at a local bank branch and filling out an extensive application form that includes employment history, salary, assets and liabilities, as well as a description of the house. After we have completed the application, the bank employee thanks us for choosing her bank and then tells us that we can expect to hear in three to four weeks whether the mortgage application has been approved.

One bank vice president, well familiar with the normal cycle time of 26 days to process such requests, asked employees to keep track of how much time was spent actually processing the application during the 26 days. The answer turned out to be about 15 minutes of work, spread over 26 days: an MCE ratio of 0.0004 (0.25 hours/[26 days * 24 hours per day]) . The vice president set a target to reengineer the approval process so that it would take only 15 minutes from completion of the application to a decision. This target corresponded to an MCE of 1.0. Bank personnel could continue to do all of the value-added processing work but had to eliminate all the non-value-added waiting times. At first, all of the employees involved in the mortgage approval process claimed that this was an impossible target. Among other tasks, credit references had to be requested and confirmed, a process that took at least a week or two. Further study revealed that credit references could be accessed on-line for almost all possible customers. Much of the analytic work and approval routines could also be

automated. A reengineered mortgage approval process, supported by enhanced information technology, was designed that yielded a decision within 15 minutes. After customers filled out the mortgage request, they were directed to a cafeteria for a cup of coffee, and by the time they returned, a decision was available.[7] A 15-minute one-stop mortgage approval process turned out to be highly attractive to a broad market segment of customers.

Similar studies in other service industries yielded similar conclusions: long cycle times for customer service during which actual processing time was remarkably low. Automobile rental companies and a few hotel chains have now automated, for targeted customer segments, all aspects of check-in and check-out, enabling valued customers to bypass all waiting in line when initially accessing the service and upon completion of the service delivery process. Thus, companies attempting to deliver products and services on demand to targeted customers can set objectives to have MCE ratios approach 1, thereby producing dramatically shortened lead times to customer orders.

Process Quality Measurement

Almost all organizations today have quality initiatives and quality programs in place. Measurement is a central part of any quality program, so organizations are already familiar with a variety of process quality measurements:

- Process parts-per-million (PPM) defect rates
- Yields (ratio of good items produced to good items entering the process)
- First-pass yields
- Waste
- Scrap
- Rework
- Returns
- Percentage of processes under statistical process control

Service organizations, especially, should identify the defects in their internal processes that could adversely affect costs, responsiveness, or customer satisfaction. They can then develop customized measures of quality shortfalls. Chemical Bank, profiled in a case study in Chapter 8, as one of its measures of service quality, developed an index called Trailway to Trolls (trolls are unhappy customers) to indicate the defects in its internal processes that lead to customer dissatisfaction. The index included items such as:

- Long waiting times
- Inaccurate information
- Access denied or delayed
- Request or transaction not fulfilled
- Financial loss for customer
- Customer not treated as valued
- Ineffective communication

Process Cost Measurement

Amidst all the attention to process time and process quality measurements, one might lose sight of the cost dimension of processes. Traditional cost accounting systems measure the expenses and efficiencies of individual tasks, operations, or departments. But these sys-

tems fail to measure costs at the process level. Typically, processes such as order fulfillment, purchasing, and production planning and control use resources and activities from several responsibility centers. Not until the advent of activity-based cost systems could managers obtain cost measurement of their business processes.

In general, ABC analysis will enable organizations to obtain process cost measurements that, along with quality and cycle time measurement, will provide three important parameters to characterize important internal business processes. As companies use either continuous improvement (such as total quality management) or discontinuous improvement (such as reengineering or business process redesign) of important internal business processes, the three sets of measurements—on cost, quality, and time—will provide data on whether the goals of these improvement programs are being achieved.

Cost of Quality

Companies, during the 1980s, developed a measure, *cost of quality*, that integrated quality with cost considerations. Before 1980, quality advocates found it difficult to get senior management attention and commitment to a total quality control program. Although agreeing in principle that better quality was preferable to lesser quality, the executives still devoted their efforts to actions that promised immediate impact on short-term financial performance as measured by earnings per share and return on investment. Relative to these financial measures, improvements in quality represented an abstract, somewhat intangible, target.

To overcome this indifference to quality improvement, quality advocates devised a financial approach to quality that they hoped would capture the attention of senior, financially oriented managers. The cost of quality (COQ) approach collects all costs currently being spent on preventing defects and fixing them after they have occurred. The cost of quality, also called the cost of nonconformance, attempts to compute a single aggregate measure of all the explicit costs attributable to producing a product that is not within specifications. It is a comprehensive, plant- or companywide financial measure of quality performance.

The costs of nonconformance can be classified into four categories:[8]

1. Prevention: The costs of designing, implementing, and maintaining an active quality assurance and control system; includes the costs of design and process engineering, quality control systems, quality planning, and quality training
2. Appraisal: The costs of ensuring that materials and products meet quality conformance standards; includes the costs of inspecting raw materials and purchased parts, inspecting in-process and finished products, lab tests, quality audits, and field tests
3. Internal failure: The costs of manufacturing losses from materials and products that do not meet quality standards; includes the costs of scrap, repair, rework, upgrade, downtime, and discounts on sales of substandard parts and materials
4. External failure: The costs of shipping inferior-quality products to customers; includes the costs of handling customer complaints and claims, warranty and replacement costs, and freight and repairs of returned merchandise

The cost of quality metric typically includes only costs already being recorded somewhere in the company's cost system; not included are unrecorded or opportunity costs (such as lost future sales) or the difficult-to-measure costs of disruption caused by out-of-conformance purchased materials and produced goods. The goal of a cost of qual-

ity measurement exercise is simply to identify how much the organization is currently spending on quality. Most companies are surprised to learn that they are currently spending between 15% and 20% of sales revenue on quality-related costs. This figure can then be used as the lever to get top management's attention that perhaps this large amount can be reduced significantly by a wiser allocation among the four quality categories.

In particular, companies that have been paying little attention to quality, choosing implicitly to inspect quality in rather than to design it in, incur large costs in the internal and external failure categories (fixing bad items after they have been built). They also spend heavily in the appraisal category. One semiconductor company adopted a total quality control program after it estimated that it would need more inspectors than workers to achieve, under current operating procedures, the quality levels demanded by its customers. An electronics instrument company learned that it was far cheaper to detect and replace a faulty two-cent resistor at the start of the production process than to repair and perhaps replace the $5,000 piece of equipment containing this part, after the instrument had been installed at the customer's site.

Such companies discovered that by spending more in the prevention category, they could greatly reduce the amount spent in the internal and external failure categories. As product design, vendor relations, and process control improved (again by increasing investments in prevention), the companies could also substantially reduce the costs they incurred in the appraisal category. Far less inspection was required once quality was designed into products and processes. Thus, by monitoring total costs of quality and their distribution among the four categories, a company could assess the decline in total quality costs as it shifted efforts from inspection and repair back into prevention.

Although cost of quality measurement is attractive when used in the above fashion, it cannot be the sole basis for measuring the success of a total quality management program. First, as are most financial measures, it is a lagging indicator of quality efforts. Employees need continual feedback to guide their experiments to improve quality and eliminate waste. They cannot wait until the end of a reporting period to learn how successful they have been in their learning and improvement activities. Second, there is no long-run target for the "optimal" level of quality costs. Spending 15% to 20% of sales dollars on quality-related costs is clearly excessive, but the optimal level for cost of quality spending is unknown and undoubtedly varies from company to company. Companies have found that they can drive quality costs down to about 5% of sales, but further reductions may be counterproductive. Also, although there are high payoffs from initially shifting quality costs from the appraisal, internal failure, and external failure categories to the prevention category, the most desirable distribution among these four categories is unknown. Often, companies can, just by being more effective and efficient with their prevention programs, lower internal and external failure costs without having to increase spending on prevention and appraisal.[9] Furthermore, the allocation of quality costs in and among the four categories is a subjective exercise that requires reasonable but still arguable judgments. Thus, the data provide a useful managerial summary of quality efforts and progress, but they probably do not provide a good basis for performance evaluations.

Also, however the existing costs are aggregated among the four cost of quality categories, the total cost of producing bad-quality items will still be underestimated. Omitted from the calculation are the costs of disruption in operations caused by out-of-conformance purchases and production and the loss of sales caused by actual external failures

and associated reputational effects. Although some of the cost of production scheduling, setups, and engineering change orders can be assigned to one or more of the categories, the implicit cost of factory confusion and excessive inventory levels may be difficult to track down.

In summary, the cost of quality measurement appears to be valuable to gain the attention of senior management: to make them aware of, first, how much the company is currently spending to produce out-of-conformance items and, second, how, by reallocating effort from detection and repair categories to prevention, it can realize substantial benefits. But nonfinancial quality measures (e.g., yield, PPM defect rates—both internal and external, and measures of scrap, rework, and unscheduled machine downtime) provide more timely, objective feedback to employees and serve as better targets for their quality improvement efforts.

Supplier Relationships

For many companies, especially those in manufacturing assembly operations (such as electronics, optical equipment and instruments, automobile, aerospace, and agricultural equipment industries) and in retailing, success is driven by having superb suppliers and supplier relationships. These companies depend critically on their suppliers to achieve their price, quality, and lead time goals with customers. When excellent supplier relationships are critical for strategic success, companies develop supplier rating systems. The systems identify which vendors have been certified—for direct, on-floor delivery without inspection—and which vendors require inspection for incoming items. Quality measures, both the frequency of defects and the percentage of dollars defective, are computed and tracked for each vendor. In addition to such incoming quality measures, the company can track on-time performance and price trends.[10]

Innovation Measures

For many companies, particularly those in pharmaceutical, semiconductor, computer, telecommunications, and chemicals industries, the value created during the innovation process may be even more important than the value created by operational excellence. For these companies, measures of excellence for the design and development processes for new products and services are particularly important.

During the product or service design and development processes, the organization's research and development group:

- Performs basic research to develop radically new products and services for delivering value to customers
- Performs applied research to exploit existing technology for the next generation of products and services
- Conducts focused development efforts to bring new products and services to market

Historically, little attention has been devoted to developing performance measures for product design and development processes. Such inattention could have been caused by several factors. Decades ago, when most organizations' performance measurement systems were designed, the focus was on manufacturing and operational processes, not on research and development. This was a rational focus since far more money was being spent in production processes than in R&D processes, and the key to success was efficient

manufacture of high-volume products. Today, however, many organizations gain competitive advantage from a continued stream of innovative products and services, so the R&D process has become a much more important element of a business' value chain. The success of this process should be motivated and evaluated by specific objectives and measures.

The increased importance of the research and development process has also led to organizations' spending much more money in their R&D processes. In fact, some businesses spend more in their research, design, and development processes than they do to support their production and operating processes. Many companies' performance measurement systems, however, remain anchored to operational efficiencies rather than to the effectiveness and efficiency of their research and development processes.

Of course, the relationship between inputs expended (on salaries, equipment, and materials) during R&D processes and the outputs achieved (innovative products and services) is much weaker and less certain than in manufacturing processes, in which standards can relatively easily be established for the conversion of labor, materials, and equipment resources into finished goods. A typical product development process in the electronics industry could have two years of product development followed by five years of sales. So the first success indicator of a product's development process may not appear for three years (the first year after the initial year of sales). Manufacturing processes with cycle times measured in time intervals ranging from minutes to several days are much more amenable to the use of standards, yields, and a variety of productivity measures for evaluation and control. But difficulty in measuring the conversion of inputs to outputs in R&D should not prevent organizations from specifying objectives and measures for such a critical organizational process. Companies should not fall into the trap of "if you can't measure what you want then want what you can measure."

Measures for Product Development

Despite the inherent uncertainty in many product development activities, consistent patterns can still be found that can be exploited in a measurement process. For example, pharmaceutical product development goes through a systematic, sequential process that starts with screening large numbers of compounds, then investigating promising ones in more detail, moving from laboratory to animal testing, shifting from animal testing to human testing, and then traversing through complex governmental review and certification processes. Each stage can be characterized by measures such as yields (number of compounds that successfully pass to the next stage divided by number of compounds that entered from the prior stage), cycle time (how long do compounds stay in a stage), and cost (how much was spent processing compounds in a stage). Managers can establish objectives to increase yields and reduce both cycle times and cost at each stage of the development process.

An electronics company did a root cause analysis of the high time and cost of its new product development process. The analysis revealed that the number one cause for long-time-to-market of new devices was products that failed to function properly the first time they were designed and hence had to be redesigned and retested, often several times. Therefore, the company retained time-to-market as a critical outcome measure for the product development process, but it added a performance driver measure: the percentage of products for which the first design of a device fully met the customer's functional spec-

ification. Another performance driver was the number of times the design needed to be modified, even slightly, before it was released for production. The company estimated that each design error cost $185,000. With an average of two errors per product introduced, and with 110 new products introduced each year, the total amount spent on design errors was about $40,000,000, an amount that represented more than 5% of revenue. Added to this calculation must be the value of sales lost from late market introduction of new products caused by the time delays of redesigning the products to eliminate the errors.

Hewlett-Packard engineers developed a metric called break-even time (BET) to measure the effectiveness of its product development cycle.[11] BET measures the time from the beginning of product development work until the product has been introduced and has generated enough profit to pay back the investment originally made in its development (see Exhibit 11-1). BET brings together in a single measure three critical elements in an effective and efficient product development process. First, for the company to break even on its R&D process, it must recover its investment in the product development process. So BET incorporates not only the outcome from the product development process but also the cost of the design and development process. It provides incentives to make the product development process more efficient. Second, BET stresses profitability. Marketing managers, manufacturing personnel, and design engineers are encouraged to work together to develop a product that meets real customer needs, including offering the product in an effective sales channel at an attractive price, at a cost that enables the company to earn profits that will repay the product development investment cost. And third, BET is denominated in time: It encourages the launch of new products faster than the competition so that higher sales can be earned faster to repay the product development investment.

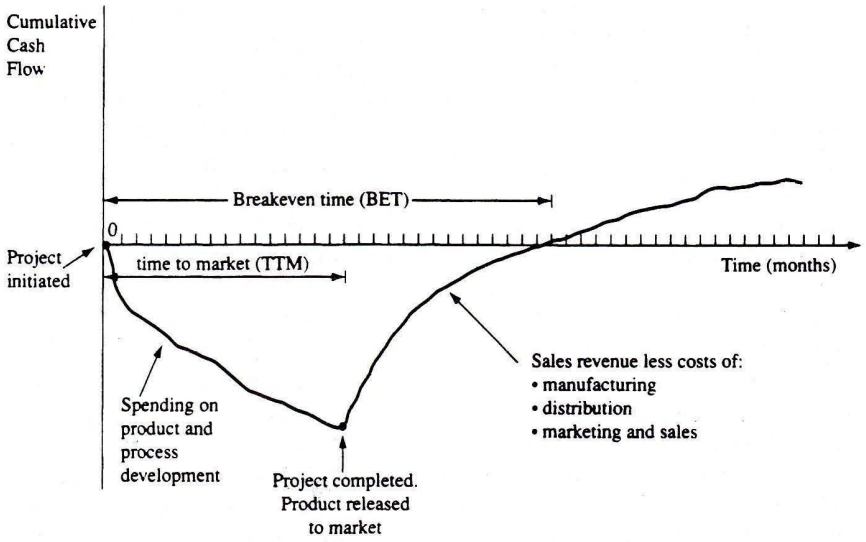

EXHIBIT 11-1 Breakeven Time

EMPLOYEE CAPABILITIES

The fourth perspective on a company's Balanced Scorecard focuses on employee capabilities. Investing to enhance the capabilities and performance of employees provides the platform for ongoing learning and improvement, a precondition for real future growth.

One of the most dramatic changes in management thinking during the past 15 years has been the shift in the role of organizational employees. In fact, nothing better exemplifies the revolutionary transformation from industrial age thinking to information age thinking than the new management philosophy of how employees contribute to the organization. The emergence of giant industrial enterprises a century ago and the influence of the scientific management movement left a legacy in which companies hired employees to perform well-specified and narrowly defined work. Organizational elites—the industrial engineers and managers—specified in detail the routine and repetitive tasks expected of individual workers and established standards and monitoring systems to ensure that workers performed them just as designed. Workers were hired to do physical work, not to think.

Today, almost all routine work has been automated: Computer-controlled manufacturing operations have replaced workers for routine machining, processing, and assembly operations, and service companies are, increasingly, giving their customers direct access to transactions processing through advanced information systems and communications. In addition, doing the same job over and over, at the same level of efficiency and productivity, is no longer sufficient for organizational success. For an organization just to maintain its existing relative performance, it must continually improve. And, if it wants to grow beyond today's financial and customer performance, adhering to standard operating procedures established by organizational elites is not sufficient. Ideas for improving processes and performance for customers must increasingly come from front-line employees who are closest to internal processes and the organization's customers. Standards for how internal processes and customer responses were performed in the past provide a baseline from which improvements must continually be made. They cannot be a standard for current and future performance. This shift requires major reskilling of employees so that their minds and creative abilities can be mobilized for achieving organizational objectives.

Core Employee Measurement Group

We have found that most companies use employee objectives drawn from a common core of three outcome measurements. These core outcome measurements are then supplemented with situation-specific drivers of the outcomes. The three core employee measurements are:

- Employee satisfaction
- Employee retention
- Employee productivity

Within this core, the employee satisfaction objective is generally considered to be the driver of the other two measures, employee retention and employee productivity.

Measuring Employee Satisfaction

The employee satisfaction objective recognizes that employee morale and overall job satisfaction are now considered highly important for most organizations. Satisfied employees are a precondition for increasing productivity, responsiveness, quality, and customer

service. One company noticed early in its Balanced Scorecard implementation process that employees who scored highest in the satisfaction surveys tended to have the most satisfied customers. So companies that want to achieve a high level of customer satisfaction may need to have the customers served by satisfied employees.

Employee morale is especially important for many service businesses, in which, frequently, the lowest paid and lowest skilled employees interact directly with customers. Companies typically measure employee satisfaction with an annual survey or a rolling survey, in which a specified percentage of randomly chosen employees is surveyed each month. Elements in an employee satisfaction survey could include:

- Involvement with decisions
- Recognition for doing a good job
- Access to sufficient information to do the job well
- Active encouragement to be creative and to use initiative
- Support level from staff functions
- Overall satisfaction with company

Employees would be asked to score their feelings on a scale of 1 to 3 or 1 to 5, anchored at the low end with "Discontented" and at the high end with "Very (or Extremely) Satisfied." An aggregate index of employee satisfaction could then be calculated, with executives' having a drill-down capability to determine satisfaction by division, department, location, and supervisor.

Measuring Employee Retention

Employee retention captures an objective to retain those employees in which the organization has a long-term interest. The theory underlying this measure is that the organization is making long-term investments in its employees, so any unwanted departure represents a loss in the intellectual capital of the business. Long-term, loyal employees carry the values of the organization, knowledge of organizational processes, and, we hope, sensitivity to the needs of customers. Employee retention is generally measured by percentage of key staff turnover.

Measuring Employee Productivity

Employee productivity is an aggregate outcome measure of the impacts of employee skills and morale, innovation, internal process improvement, and customer satisfaction. The goal is to relate the output produced by employees to the number of employees used to produce that output. There are many ways in which employee productivity has been measured.

The simplest productivity measure is revenue per employee. This measure represents how much output can be generated by each employee. As employees and the organization become more effective in selling a higher volume and a higher value-added set of products and services, then revenue per employee should increase.

Strategic Job Coverage

Several organizations, in different industries, have developed a new employee-based measure, the strategic job coverage ratio, for its reskilling objective. To calculate this ratio, managers must first define the set of skills that employees in critical front-line and man-

agerial jobs must possess if they are to do that job effectively and deliver the organization's strategy from that organizational position. Then the managers must measure the knowledge and skills currently possessed by the employees in those positions and whether, with these skills and knowledge, they can deliver the key capabilities for achieving particular financial, customer and internal business process objectives. The strategic job coverage ratio is then calculated as the percentage of strategically critical jobs filled with qualified employees.

Usually, the strategic job coverage ratio reveals a significant gap between present competencies—as measured along dimensions of skills, knowledge, and attitudes—and future needs. This human resource staffing gap provides the motivation for strategic initiatives designed to close it. For organizations requiring massive reskilling, another measure could be the length of time required to take existing employees to the new, required levels of competency. If the massive reskilling objective is to be met, the organization itself must be skillful in reducing the cycle time required for each employee to achieve the reskilling.

SUMMARY

Measures on customers, internal business processes—both operations and innovation—and employees provide companies with the leading indicators of creation of long-term economic value. Financial measures provide adequate indicators of past performance but fail to signal contemporary improvement or decrement in organizational capabilities. In this chapter, we identified how managers can select measures to help them communicate, motivate, and evaluate the drivers of future financial performance. Having a balanced set of financial and nonfinancial measures, explicitly derived from and linked to the business unit's strategy, will enable companies to manage both short- and long-term value creation.

ENDNOTES

1. F. F. Reichheld, *The Loyalty Effect* (Boston: Harvard Business School Press, 1996); F. F. Reichheld, "Learning from Customer Defections," *Harvard Business Review* (March–April 1996); and J. L. Heskett, W. E. Sasser, and L. A. Schlesinger, *The Service Profit Chain* (New York: Free Press, 1997).
2. T. O. Jones and W. E. Sasser, "Why Satisfied Customers Defect," *Harvard Business Review* (November–December 1995), pp. 88–99.
3. R. S. Kaplan, "In Defense of Activity-Based Cost Management," *Management Accounting* (November 1992), pp. 62–63.
4. The interplay among customer acquisition, retention, and lifetime profitability is at the heart of the comprehensive measurement system proposed in Reichheld, *Loyalty Effect*, chapter 8. The approach advocated by Reichheld, including explicit incorporation of the value drivers to and from the customer, is highly compatible with the approach we have articulated for the customer perspective of the Balanced Scorecard.
5. See examples in R. S. Kaplan and D. P. Norton, *The Balanced Scorecard: Translating Strategy into Action* (Boston: Harvard Business School Press, 1996), pp. 73–84.
6. C. Hart, "The Power of Unconditional Service Guarantees," *Harvard Business Review* (July–August 1988), pp. 54–62; J. Heskett, E. Sasser, and C. Hart, *Service Breakthroughs: Changing the Rules of the Game* (New York: Free Press, 1990).

7. Some aspects of the application could not be verified within 15 minutes. An approval decision was made contingent on the information supplied on the application being valid, including employment history, salary, and market value of purchased house. This information would be confirmed during the next several days. But the analytic work and the credit record check could be accomplished within the 15-minute processing window.
8. See W. Morse and H. P. Roth, "Let's Help Measure and Report Quality Costs," *Management Accounting* (August 1983), pp. 50–53; J. Clark, "Costing for Quality at Celanese," *Management Accounting* (March 1985), pp. 42–46: and W. Morse and H. P. Roth, *Quality Costs* (Montvale, NJ: National Association of Accountants, 1987).
9. C. D. Ittner, "Exploratory Evidence on the Behavior of Quality Costs," *Operations Research* (January–February 1996), pp. 114–30.
10. See C. D. Ittner and L. P. Carr, "Measuring the Cost of Ownership," *Journal of Cost Management* (Fall 1992), pp. 42–51.
11. C. H. House and R. L. Price, "The Return Map: Tracking Product Teams," *Harvard Business Review* (January–February 1991), pp. 92–100; also M. L. Patterson, "Designing Metrics," in *Accelerating Innovation: Improving the Process of Product Development* (New York: Van Nostrand Reinhold, 1993).

■ *PROBLEMS*

11-1

The Stoneland Company was in the construction business. In building its Balanced Scorecard, managers interviewed many of its current and potential customers. They found that some customers were highly price-sensitive and wanted to continue business as usual. These customers developed internally all the specifications for their bids, put the detailed bidding document out to tender, and chose, from among all qualified suppliers, the one submitting the lowest bid. As one price-sensitive customer said during an interview:

> We don't have the resources of time for doing anything fancy with our suppliers. Our business has become ruthlessly competitive, with price and margin reductions in recent years, and the need for us to cut costs wherever we can. We can't afford to choose anyone but the lowest-price supplier.

Historically, Stoneland competed by attempting to be the selected low-price bidder for price-sensitive customers.

But the interviews also revealed that several large and important customers were looking for more than low price from their most valued supplier of construction services. They said:

> We have to cut costs wherever we can. But we are looking to our suppliers to help us in this goal. If it's cheaper and more effective for them to take over some of our engineering functions, we should let them do that, and reduce our internal engineering staffs accordingly. We don't have any special capabilities in construction. We want suppliers that can suggest new ways of doing business, and who can develop improved technologies for this task. Our best suppliers of engineering and construction services will anticipate our needs and suggest creative ways to meet these needs through new technologies, new project management approaches, and new financing methods.

These companies acknowledged that rapidly changing technology and an increasingly competitive marketplace for their final products had motivated them to look to their suppliers for innovative ways to lower their costs. Although price would still be a factor, a supplier's ability to offer innovative and more cost-effective approaches would be a strong influence on supplier selection. Stoneland referred to these companies as those wanting *differentiated services*.

Required

(1) How would the customer and internal business process perspectives of Stoneland's Balanced Scorecard differ, depending on whether it selected the price-sensitive or differentiated services customer types as the target for its future strategy? Be specific about how the measures would differ depending upon which strategy Stoneland followed.
(2) What new internal business processes would Stoneland have to perform very well if it wanted to meet the expectations of its customers wanting differentiated services?

11-2

Kenyon Stores, a large clothing retailer, developed an image of who its targeted customers were.

- Range: 20- to 40-year-old female (target: 29 years)
- College-educated
- Works full-time in professional executive position
- Innovatively fashionable
- Self-confident, great sense of humor

It then communicated this targeted customer image externally, through a variety of advertising and in-store promotional materials.

By communicating a clear image to potential customers, the store enabled its existing and future customers to imagine themselves as fitting an image associated with purchasing clothes at Kenyon Stores. The company creates for its customers an image of who they can be, in addition to selling them fashionable clothing of high quality at reasonable prices.

Kenyon Stores started the development of its customer objective by defining a customer strategy:

1. Kenyon must increase its customer share of wardrobe
2. Increased share of wardrobe will be achieved by *customer loyalty*: "We want the customer to visit us throughout the year and come to Kenyon for the complete range of her lifestyle needs."
3. To create this loyalty:
   - Our *Merchandise* must define our customer, her needs, and her aspirational image
   - Our *Brand* must satisfy the customer's aspirational and lifestyle goals
   - Our *Shopping Experience* must promote customer loyalty
4. We must do a superb job of defining who our customers are and their buying behavior.

Kenyon identified three objectives as key product attributes for its consumers' value proposition: price, fashion, and quality. The price objective was stated as: "Provide fashion and quality that the customers perceive as high-value and consider to be fairly

priced." The fashion objective was to: "Provide fashionable merchandise that satisfies our customer's aspirational and wardrobe needs within the Kenyon brand." The quality objective was to: "Ensure the highest quality and consistency of fit both within a style and across all product categories."

The shopping experience dimension was considered extremely important. Key attributes were availability of merchandise and the in-store shopping experience. The in-store shopping experience dimension was captured by an explicit vision of the six elements of the "perfect shopping experience":

1. Great looking stores with fashion impact
2. Customer welcomed by attractive associates, fashionably dressed, with a smile on their faces
3. Clear communication of special sales
4. Associates with good product knowledge
5. Personal name recognition by attending associate
6. A sincere thanks and an invitation to return soon

The goal was to deliver the six elements every time the customer enters a store.

Kenyon had constructed a very specific definition of its "ideal shopper." The ideal shopper image communicated to all employees the fashion expectations of their customers. The brand image objective for Kenyon was stated as: "We will build Kenyon into a dominant national brand by clearly understanding our target customer and differentiating ourselves in meeting her needs."

Required

Select appropriate measures for Kenyon's customer and internal business process perspectives.

11-3

Consider a semiconductor manufacturer, competing in an industry with extremely rapid technological change. What measures might be appropriate for such a company's innovation process?

11-4

In the chapter, we discussed the use of several measures of the innovation process, including *percentage of sales from new products* and the *breakeven time* (BET) metric. Although both measures are attractive for communicating the economics and benefits from successful product development processes, each also has some limitations and dysfunctional consequences if managers focus too narrowly on them as a performance measure. Identify the potential limitations and weaknesses of both these outcome measures of the new product development process.

11-5 *The Way Things Were*

"Hi, John. How are things going out on the line?"

"Hi, Fred. Not bad, not bad at all, though I had to be careful the last couple of days. Someone from IE standards was following me around and I had to go back and work the way we used to do it. I didn't want to get him all upset by seeing the new way we go about our jobs."

"What do you mean? Have you found a new way to sandbag without them noticing?"

"Not at all. We're working smarter, thanks to our department manager, Monty. It all started several months ago when our output went way down even though all the efficiency measures said we were on target."

"How can that occur?"

"Basically, Monty discovered that most of our time was not spent working on producing good items. Let me give you an example. For one of our products we have to perform four welds to attach some metal parts together. We have detailed standards telling us how long it should take to do each step.

"One day, Monty watched Mike do these welds. Everything was done by the numbers. Mike walked over to the WIP storage area, picked out enough parts to prepare 10 products, put them on a dolly, and wheeled them over to his workstation. Then he read the job card telling what he had to do and which tools were needed. He grabbed the right tools from his tool crib, set his jig to fixture the parts into place, and proceeded to weld the parts together into the 10 units. After finishing the 10 units, Mike inspected them all, rejecting one because the hole in one of the parts had been drilled incorrectly in a previous operation, put the nine good parts on the dolly, wheeled them to the next storage area, and then put the one rejected part into the rework area.

"The whole process took about 100 minutes from start to finish—100 minutes to produce nine good subassemblies. But then Monty watched what happened to the nine items Mike had just finished. An inspector in a white coat was testing the welds in some kind of new X-ray device we had bought and ended up rejecting two more subassemblies. Then another guy came around to put tags on the two rejected items with a brief description of the problem and then took them to the rework area. And that wasn't all. Monty noticed someone counting inventory to make sure it corresponded to the job card attached to the batch and other people doing tests on tools and fixtures. There were more people checking work and moving parts than there were actually doing the work.

"Monty went bananas. He called over one of the IEs who (unfortunately for him) happened to be walking by at the time. Monty yelled at him, 'I just watched one of my workers spend 100 minutes to weld parts for 10 subassemblies, and three of them were rejected after finishing, 100 minutes to get seven good parts, 28 good welds. Near as I can tell, each weld takes about one minute to do. Is this normal—to spend 100 minutes to get 28 good welds?'

"The IE attempted to explain to Monty about scientific management and how standards for work and productivity were computed. First the IE confirmed Monty's observation. The standard time to do one weld is 1 minute and 7 seconds. But there were standards for getting the parts and fixturing them into place, standards for assembling and

preparing tools, standards for inspection and small repairs, and standards for moving the parts to the next storage area. They even had an allowance for break time and idle time due to line imbalances. Everything had been measured and accounted for. In fact, the total standard time for the 10 units that Mike had done came to 108 minutes, so Mike's 100 minutes was considered good performance—about an 8% productivity improvement.

"This really got Monty riled up. Monty figured that he got 28 good welds from Mike which, according to the IE's standards, should have taken a little over 30 minutes. So right away, Monty figures that productivity was only around 30% of what's possible, not the 108% the IE was attempting to explain to him. Then he started thinking about all the other people who were standing around inspecting and moving things but who never did any work on the parts themselves. By the time he finished estimating the number of people he had in quality control, maintenance, and storing and handling things, he figured that there was at least one indirect worker for each guy like Mike who actually worked on products. Therefore actual productivity was only about half the 30% he computed initially."

"I can imagine he was upset. But what did he do about it?"

"Monty had the QC people analyze what caused the problems with the two parts that had been rejected after Mike had welded them. It turned out the materials were not exactly within specification and therefore didn't take the welds the way they were supposed to. So Monty took off down to the purchasing department to see why substandard materials had gotten through the system. He found out that this particular batch of materials had been bought from a new supplier. The purchasing guy was spending all his time trying to lower costs, and he had just uncovered this new vendor who agreed to supply parts 4% cheaper than the standard purchase price. I wish I had been there when the head of purchasing attempted to explain to Monty why it was cheaper to buy from this new supplier, when 20% of the subassemblies eventually had to be reworked or scrapped."

"All that running around and screaming couldn't have made Monty very popular."

"Wait—he wasn't finished. A few days later, a rush job that was already several weeks late got delayed further when a machine broke down in the middle of the run. It took maintenance people several days to get replacement parts and another couple of days to install them and get the machine running properly again. During this time, when everyone was waiting for the repairs so that we could finish the job, Monty dispatched a couple of workers to find out when the machine had last been serviced. Apparently there is a schedule for preventive maintenance, but the shop had been so busy that no one wanted to interrupt work to do maintenance; so it had gotten delayed and eventually the maintenance department had apparently forgotten to reschedule it. This didn't bother the maintenance foreman too much because his people were so busy responding to emergencies, like the one we had, that they didn't have much time to do regularly scheduled maintenance.

"Many of the foremen don't like to have maintenance done on their shift either. They get evaluated by labor and machine efficiency; some kind of ratio of earned hours to hours actually paid. A sure way to get the plant accountants sending nasty letters to you is to stop producing items in order to grease the machines and replace some parts that haven't worn out yet. The accountants claim this kind of work lowers efficiency, since nothing is getting produced and the workers are idle."

"I bet Monty had his hands full doing battle with the purchasing and maintenance departments."

"Not quite. He's a scrappy fellow who doesn't let a few disagreements stop him from doing what he thinks is right. Last month he took off after his monthly performance report. I don't understand all the details of what's in these reports or how they're calculated, but he started muttering about space charges. I think that lots of overhead costs get charged to departments on the basis of the space they take up in the factory. Monty wanted to know why the department occupied so much space. He dragged in one of the IEs and had him do a quick study on how much room was needed for the machines and the people who actually worked on the product. Less than 25% of the space was taken up for machines and workers. What really set him off again was learning that the testing and rework area took up about as much space as the productive workers and machines. Monty thought it dumb that as much space was used to test for and store bad items as to produce good items."

"Sounds like you've had an interesting few months here."

"You better believe it. I've seen more changes in the last few months than we've had in the past 20 years."

Required

What operating changes do you think Monty instituted? What changes in the accounting and measurement system would be necessary to support the operating changes?

11-6 General United

Brad Lawrence, CEO of General United, a conglomerate consisting of a dozen companies in different industries, was wondering whether cycle time should be included in the Balanced Scorecards of his operating companies. Currently, the senior managers of each company were building Balanced Scorecards that would be used to assess their strategies and to measure their performance.

One company, GND Machinery, manufactured machinery for packaging companies. GND's customers, the packaging companies, often had difficulty in estimating the demand from their customers, so they greatly valued suppliers who could provide equipment with short lead times. Lawrence felt that if GND Machinery could reduce the time it took to produce machinery to fulfill customer orders, then sales and market share would increase, perhaps dramatically.

At the other extreme, General's defense company, Bradley Aerospace, produced long-lead-time products and systems for government contracts. According to the contract terms, Bradley got no benefit from early delivery, and the contracts allowed for reimbursement of Bradley's inventory holding costs.

A third General United company, Harvest Unlimited, produced agricultural machinery. Harvest's customers generally placed orders only at the beginning of the planting season, a two-month period during the spring. Currently, the lead time to produce Harvest's products was well in excess of two months, so virtually all production was based on sales forecasts, attempting to anticipate the volume and mix of customer orders. Often the forecasts were inaccurate, leading to high inventory and obsolescence of unordered machines, as well as shortages when demand for particular machines greatly exceeded the forecast. If the production cycle time could be reduced below the two-month ordering window,

Harvest could shift some of its production schedule from producing based on forecasts to producing based on actual customer orders.

Required

What role should lead time play in the Balanced Scorecards of the three operating companies?

11-7

Some companies use revenue per employee as a simple and easy-to-understand productivity measure of its employees.

(1) Why would revenue per employee represent a useful measure of employee productivity and capabilities?

(2) What limitations or dysfunctional consequences could arise from using revenue per employee as an employee productivity measure? How could these be overcome?

11-8 National Aerospace Group—Measuring Vendor Performance (C. Ittner)

National Aerospace Group (NAG) is a leading manufacturer of military and commercial aircraft and components. With the recent consolidation in the defense industry, National Aerospace faces increasing pressure to reduce costs and improve quality. One of the largest opportunities for cost reduction and quality improvement is in materials costs, which make up 70% of the firm's cost structure. A recent study revealed that 50% of the more than 100,000 receipts from suppliers during the previous year had paperwork or hardware discrepancies or did not meet delivery schedules. These problems were conservatively estimated to cost National Aerospace $20 million annually.

The obvious need for better quality and on-time delivery from suppliers led to the development of the Supplier Performance Rating System. The system measures the added administrative costs that NAG incurs to resolve suppliers' hardware, paperwork, and delivery deficiencies. Each type of nonconformance "event" is assigned a standard cost based on a study of the hours required to resolve the problem. The number of events over the previous year is multiplied by the associated standard cost to obtain the total cost of nonconformance. A supplier performance index (SPI) is then calculated as follows:

$$\text{SPI} = \frac{\text{nonconformance costs} + \text{purchases}}{\text{purchases}}$$

The SPI is used to determine the total "cost of ownership" when selecting suppliers. For example, if the quoted price is $100 per unit and the supplier's SPI is 1.2, a value of $120 per unit is used in the supplier selection process. The 20% markup reflects the additional quality-related costs that NAG expects to incur if this supplier is selected. In addition to the SPI system, NAG conducts annual supplier audits to assess their technical and manufacturing capabilities and their assistance in cost reduction and new product development efforts. Audit scores range from a low of 0 to a high of 100.

NAG's purchasing department has just received four bids for a critical component needed for the firm's new commercial aircraft. Three of the bids are from existing suppliers; the fourth is from a highly recommended new supplier. The information in Table 1 is available on the four suppliers:

Nancy Gilbert, the head of purchasing, has called a meeting with the managers of engineering and manufacturing to review the bids. One issue is the lack of performance history on Delta Products. Discussions with other companies that have used all four suppliers indicate that Delta had the highest quality and best on-time delivery. NAG's purchasing procedures, however, require new suppliers to either be the low bidder or to have the lowest cost of ownership using the average SPI for all the bidders with performance history.

A second issue is Alpha's low audit score. Robert Bilsland, the manager of engineering, is adamant that audit scores should be considered in the decision. "Beta may have bid 15% higher than Alpha, but Beta has given us a lot more assistance in cost reduction efforts and product development. This is reflected in Beta's audit score, which is 40 points better than Alpha's audit score. We should weight audit scores at least 50% when selecting the supplier."

Given the importance of this component and the large number of units that need to be purchased, the managers realize that the contract should go to the supplier offering the best overall value to NAG, rather than the lowest quoted price.

Required

(1) Calculate the adjusted bids from Alpha, Beta, and Gamma after taking into account the SPI. On the basis of the cost of ownership, which supplier is the lowest cost?

(2) Calculate the adjusted bid from Delta using the average SPI for Alpha, Beta, and Gamma. How does this adjusted bid change the supplier selection decision? Should this method be used for evaluating bids from new suppliers?

(3) Assume that NAG decides to place a 50% weight on audit scores and a 50% weight on the SPI-adjusted bids. Also assume that Delta would receive the average audit score from the other three bidders. Would these conditions change the supplier selection decision? Should the supplier audit be considered in the selection process?

TABLE 1

	STANDARD COST PER EVENT	ALPHA	BETA	GAMMA	DELTA
Quoted price/unit		$100	$115	$130	$105
Purchasing History					
Total purchases		$250,000	$200,000	$750,000	$0
Number of events					
Documentation errors	$ 79	5	0	2	N/A
Return to supplier	300	2	0	0	N/A
Rework	837	8	5	0	N/A
Undershipment	350	1	2	0	N/A
Overshipment	112	0	1	1	N/A
Late delivery (weeks)	500	8	2	0	N/A
Audit score		60	100	80	N/A

■ CASES

DRAPER INSTRUMENTS*

At exactly two o'clock on the afternoon of February 8, 1992, Bill Wilcox, Manufacturing Manager of Draper Instruments, stepped into the conference room, motioned for quiet, and began to speak.

> As you know, we're here to discuss the possibility of introducing a new system of production control, Toyota's Just-in-Time system. All of you, I hope, have reviewed the materials that I sent around last week, outlining the project and providing a brief description of how the system works in Japan. Since this is our first meeting, I'd like to spend the next few hours reviewing the major elements of Just-in-Time and considering how it might be applied in Draper.
>
> To help answer your questions, I've invited Mark Kraft to join us at today's meeting. Mark is the president and founder of a consulting firm specializing in operations planning and control, as well as a leading expert on inventory management.
>
> I suppose some introductions are in order now. Working clockwise around the table, we have Sam Magnuson, manager of production control; David Petty, manager of planning; Bob Colson, a production control supervisor; Eric Samuels, first-line supervisor; and Henry Nelson, manager of shop operations.
>
> One final comment before I give Mark a chance to speak. You all know that inventory has been a perennial problem for us and that something must be done to bring inventory levels down. That's the whole purpose of this project. My personal view, after visiting a number of Japanese factories, is that our goals are relatively modest. We're shooting for a reduction in inventory from the present level of $6.2 million to $2.1 million after three years, with a further reduction to $1.4 million or less after five years. Some of the Japanese companies we visited carried only six to eight days worth of inventory; many didn't even have stockrooms. I don't see why we can't do as well.

Plant Issues

Most of Draper's hourly workers were paid on an incentive wage system, based on piece rates that had not been reviewed for several years. Standards were tighter for some parts than for others. Because workers normally had considerable autonomy in the parts they chose to make, they often focused on those with the loosest standards rather than on those that were in the greatest demand. The result was excess supplies of some parts and shortages of others. One product, for example, which an experienced worker could make at 150% of standard, had an inventory level estimated at six weeks' usage under normal demand conditions. One plant employee, commenting on the problem, observed: "How can anyone keep them [the workers] from making whatever they want? All of the materials they need are right there on the floor. The supervisor would have to watch every move those guys made to keep them making the right parts. And the union certainly won't stand for such intervention all of a sudden." In fact, several managers had noted a strong correlation between the tightness of standards and the percentage of time that parts appeared on the critical list (indicating a parts shortage).

Sheet metal welders, who were the most highly paid and most senior group of hourly workers, presented an additional problem.

*Adapted from General Electric—Thermocouple Manufacturing (A), Harvard Business School case 9-684-040, and (B), Harvard Business School case 9-685-002.

Several managers suspected that they were using the incentive system to their own advantage. Because the rate for reworking defective parts was higher than the rate for welding them in the first place, welders benefited from building in their own defects. As one manager noted: "Although the welding equipment that the welders have to work with isn't the greatest, I don't see how there could be a 22% defect rate without some help from them. But what can we do? No one has supervised those guys for years."

Managers believed that the emphasis placed on efficiency ratings had even encouraged foremen to bypass the production control system. For example, raw materials for resistors were left unmonitored on the shop floor. Because the foreman in charge of resistor assembly had ready access to these materials, and because he wished to maintain a high efficiency rating, he had instructed his people to make resistors every time they were without other work. Only when the inventory numbers rose steadily for two months in a row did Wilcox discover the problem. By then, $55,000 worth of resistors had been built (out of a total inventory on hand of $160,000). Moreover, demand for this type of resistor was expected to cease in December 1993, leaving $38,000 worth of obsolete parts

In addition to internal workforce issues, Draper's most important supplier, whose quality and reliability had historically been high, was currently in decline. Rumors were circulating that the plant was soon to be closed. Draper's management, however, did not feel that replacement suppliers should be approached until there was some official announcement about the supplier's future.

Inventory Management

Draper used a production control system, called the Inventory Control Package (ICP), to manage inventories. ICP was a variant of material requirements planning (MRP), in that it exploded backward to determine raw materials needs. The system had been ordered from an outside consulting firm, which had not fully integrated it into Draper's operations. In-house systems people had therefore found it necessary to introduce modifications. Many of these changes were undocumented, and the people who had introduced them were no longer at Draper.

Production was planned on a monthly basis. Therefore, workers could theoretically be building product up to four weeks ahead, adding that much more work-in-process inventory. If production were planned on a weekly basis, the problem would be greatly reduced. However, the production planning department was not optimistic about this approach. One manager commented: "Those guys can't even level a monthly schedule! How do they expect to level a weekly one?"

One of Draper's most important customers contributed to the volatility in scheduling. In the past, this customer had been unwilling to commit in advance to a preset schedule. It wanted to preserve its ability to respond to last-minute orders. It was primarily these orders that caused the production schedule for finished instruments to be difficult to predict.

Materials control was relatively loose once materials left the stockroom (Draper's staff had nicknamed the shop floor "no man's land" because goods seemed to disappear there without a trace), so it was difficult to know the accuracy of the inventory balances reported by the ICP. The system was reinitialized every two months to clear old information from the computer, but this process did not reflect goods already on the shop floor. Once these goods left the stockroom, there was no further accounting of them until the yearly physical inventory. For one instrument, inventory on the production floor was estimated at between $300,000 and $315,000, approximately 80% to 85% of the total inventory on hand for that particular product line.

Loss factors, representing the percentage of raw materials expected to end up as scrap, had not been reviewed for several years. These normally reflected either yield losses on the production floor or rejects from incoming inspection. In 1991, these losses totaled 6.3% of sales. However, certain items were being purchased in as much as double the actual quantity needed because the yield on their processes had been only 50% when loss factors were initially established. Over the years, many of these processes had been streamlined; yields had often improved dramatically, although loss factors had not been similarly adjusted.

The Meeting

Mark Kraft glanced around the room as he waited for a response to his comment. In the brief silence that followed, he added, "I'd like to walk out of this room with two things: a first cut at the problems that we're going to encounter when this program is implemented and a reasonable action plan, with responsibilities assigned to specific people. I'd also appreciate comments about what you perceive as being *good* about the plan."

David Petty jumped in. "I feel that the biggest problem will be with our vendors. It just doesn't make sense to talk about improving quality when our vendors are so unreliable. They neither produce good pieces nor deliver them on time.

"Our best vendor is having problems with a microcontroller, one of the most important parts we purchase. Just imagine what would happen if we were on a just-in-time system and the microcontroller or some other vendor quality problem came up. With the inventory reductions that you're describing, we would have to shut down the line. Are we really willing to take such risks? Our customers wouldn't be very happy with us if our delinquency rate went any higher.

"Talking about the Japanese and their great quality with so little inventory—do they have as much pressure to meet output goals as we do? Working in the shop, production comes first, with quality way behind. We would like quality to be better, but right now, output is the driver. Hell, even you Bill, as excited as you are about inventory levels and as much as you want to improve quality, know that when it comes to the bottom line, you've got to meet the shipment schedule. In other words, our next promotion has a lot more to do with meeting shipments than with improving quality or reducing inventory."

Magnuson interrupted: "Don't we share some of the blame? Don't we keep changing the schedule? We should establish and then stick to a six- to eight-month schedule, but we're willing to change at the drop of a hat."

Wilcox nodded, then added: "Let me give an example. An important customer has just submitted a request that would make us delinquent for the month of January. Originally, we were supposed to build 30 instruments. On January 7, they came in and told us to build 65 in January and 50 a month in February, March, and April, rather than the 30 originally planned. They don't want anything in August, September, or October, but a lot more in November, then none in December because they don't want a high year-end inventory. That's the kind of schedule changes we deal with regularly. What's important is not that we get these occasionally but that we get them on the average of one a week."

Mark Kraft rejoined the discussion at this point: "We should probably spend some time discussing your production process. How much will the current process have to change to adapt to just-in-time?"

"In the future, people will have to be more versatile," said Nelson. "Believe it or not, we've already started in that direction. We're now doing a lot more cross-training."

Wilcox observed: "In Japan, the most we saw were six labor grades, and they didn't even use the first one. We have 250–300 grades in this plant alone. In the assembly area alone, we have 12–18 grades, with hourly wages ranging from $8.60 to $10.62."

"We need to reduce setup costs," said Nelson. "That's the only way that we will be able to reduce our lot sizes. For example, one of our insertion machines requires three hours of setup time for a typical run of eight hours. We'll have to completely change our thinking in this area. Until now, we've always assumed that large lot sizes were the key to profitability."

"What kind of gains could be achieved if setup times were reduced from 3 hours to 10 minutes?" asked Kraft.

"It's impossible," said Nelson.

Kraft went on: "Let's take an example to see if that's true. How long does it take you to change a flat tire on your car?"

"More than an hour," Samuels laughed.

"How long does it take to change the tire of a racing car competing in the Indianapolis 500?"

"That's different. They have trained crews. It takes them only about 15 seconds," said Nelson.

"Then," continued Kraft, "why couldn't you make similar improvements in manufacturing? Couldn't you set up a special team to do setups? Or break down the tasks and have some performed in advance?"

"It could be done in stamping," replied Samuels. "We would have to set up a special rate for the setup team, but I guess that's not impossible."

Magnuson added, "I hear that the workers in Japan do a lot of the thinking about reducing setup times. Perhaps there's some way for us to get more input from our workers."

Wilcox noted: "In one plant we visited in Japan, there were 88 suggestions from each employee each year, even though workers received only token payments for their contributions. Management tried to respond to all suggestions within a month. Those inputs from the workers can make a big difference."

"Let me introduce a new subject," suggested Kraft. "Tell me about your reject rates."

Nelson replied: "As you might expect, they vary by stage in the production process. In-process rejections, between subassembly and final assembly, run about 15%. At final inspection, the reject rate is 5%. In the field, the rate is less than 1%. That's not strictly accurate because we rework a lot before parts get to the in-process stage. At some early fabrication steps, our yield is only 60%. The major cause of this low yield is environmental contamination."

Samuels disagreed: "No, the problem is in the printed circuit boards. If you take 10 boards, no two are the same. That's why we have inconsistent quality. It's a vendor problem."

"What if," asked Kraft, "we could get the yield losses at that operation down to 25%, at final inspection to 2%, and in the field to less than 0.5%? What would that mean?"

"Great savings! Productivity increases, better product, lower inventories," enthused Samuels. "I think that we should set some goals that will get us moving in that direction."

Kraft stood up to terminate the meeting. "We've asked some very tough questions today, and you've been honest and open in your responses. If this project is going to work, that honesty will have to continue. Part of your job will be to lower the walls that now exist between the various functions represented here. You'll need to encourage a lot more cooperation for the common good. Somehow, Bill will have to figure out a way to reward you for your performance. He'll do that. But if you continue to develop cooperation and trust, you have a great opportunity. You're trying to discover a new way to manage the business. It will no longer be an inventory problem, a quality problem, a shipment problem, but *our* problem. I'm very excited about the possibilities."

Required

(1) How did the previous performance measurement system influence the production process?

(2) What new measures should Draper introduce that will motivate employees to achieve the JIT objectives and track how well they are implementing the JIT concept?

TEXAS INSTRUMENTS: MATERIALS & CONTROLS GROUP*

Although you can find a technical fault with every number, the Cost of Quality system has been successful in meeting its intended objectives. But the Cost of Quality figure probably includes only half of all the costs associated with quality and may no longer provide sufficient incentives to drive further improvements. Cost of Quality numbers should be as high as possible to aid in identifying areas for improvement. During the past five years, we have reduced the biggest boulders. Now we have a conflict between comparability and the need to redefine our measurements so that the smaller rocks become visible. Today's opportunities are mostly in indirect areas, but it would take a dramatic shift in attitude to focus on measuring indirect quality costs.

Werner Schuele, Vice President, People and Asset Effectiveness

The Materials & Controls Group was the third largest of seven major businesses within Texas Instruments. The M&C Group's activities centered on two primary technologies:

- Metallurgical Materials: M&C was currently the world's leading designer and manufacturer of industrial and thermostatic clad metals. Clad metals consisted of two or more wrought metal layers that were metallurgically bonded to offer properties not available in conventional metals. Examples of this technology included copper-clad aluminum wire, which combined the electrical conductivity of copper with lighter and lower-cost aluminum; stainless steel–clad aluminum, offering the luster of stainless and the corrosion protection of aluminum; and thermostatic metals, which enabled the controlled movement of thermostat components through the bonding of two metals with different coefficients of expansion. M&C had pioneered the application of these layered materials in uses as diverse as cookware, coinage, cable and wire shielding, integrated circuits, and corrosion-inhibiting trim for automobiles.
- Control Products: The Control Products business manufactured a wide range of products combining electronic and electromechanical technologies with TI's semiconductor and clad-metals expertise. The business operated plants worldwide in support of a strategy based on strong, long-term customer relationships, primarily at the OEM [original equipment manufacturer] level. Principal markets included the automotive, appliance, heating/ventilating/air-conditioning, general industrial, and aerospace/defense industries. The business's products offered control, regulation, signaling, and protection functions in applications such as motor protectors, relays, automotive engine controls, pressure switches, circuit breakers, thermostats, and electronic sensors.

The last decade had brought increased competition as companies from Japan, Italy, and Brazil had improved their products while lowering costs. M&C had responded by improving quality and service so that it could compete on factors other than price alone.

Organization

The Product Customer Center (PCC) served as the organizational building block within TI. PCCs had profit and loss responsibility

*This case was prepared by Christopher Ittner, under the supervision of Professor Robert S. Kaplan.

for products and customers. M&C had 11 PCCs and two Fabrication Customer Centers (FCCs) located within four operating divisions (two domestic and two international). Three additional PCCs were located in a Latin American division. Each PCC had its own marketing, engineering, finance, and manufacturing functions. FCCs manufactured components and subassemblies that were common to PCCs in order to capitalize on economies of scale and specialized expertise.

Four staff support activities existed at the group level: Research and Development, Finance, People and Asset Effectiveness (responsible for quality assurance, training, purchasing, and materials management), and Personnel/Group Services (responsible for facilities, tool making, automation, and human resources).

Quality at TI

Productivity, teamwork, and problem solving had always been important at TI. During the 1950s, work-simplification programs, the forerunner of what are now called quality circles, had been established. In the 1960s and 1970s, TI's productivity programs were expanded to include asset management as well as people effectiveness. As international competition intensified in the late 1970s, TI's People and Asset Effectiveness activities began to focus more specifically on quality improvement. Despite these trends, however, TI continued to emphasize financial controls and a quality philosophy which, while never formally stated, expected a certain amount of defective product to be returned by the customer.

In 1980, the short-run economic tradeoff approach to quality was abandoned when the company decided to commit to a "Total Quality Thrust." The new thrust was triggered when Hewlett-Packard, an important TI customer, publicized a study that had found the products of its best American suppliers to be inferior to those of its worst Japanese suppliers. TI management understood well the message from this study: Its long-run competitive success required a greatly expanded commitment to quality control.

The TI Total Quality Thrust was based on the following principles:

1. Quality and Reliability (Q&R) is management's responsibility.
2. Q&R is a responsibility of all organizations.
3. Managers' performance on Q&R will be a key criterion in performance evaluation.
4. Managers' commitments to Q&R will not be measured—only the outcomes will be.
5. The only acceptable goal for Q&R is a level that surpasses TI's best worldwide competitors at any time.

In order to emphasize that quality was not just a program but had to become TI's normal way of doing business, a vice president of People and Asset Effectiveness was appointed at the corporate level. A written policy statement, signed by the CEO, was developed and communicated. It stated:

> For every product or service we offer, we will understand the requirements that meet the customers' needs, and we will conform to those requirements without exception. For every job each TIer performs, the performance standard is: Do it right the first time.

A massive training program for all operating personnel on the fundamentals of quality improvement was undertaken. During the first phase, 450 top managers, including 22 from M&C, were sent to quality training courses conducted by Philip Crosby, a leading quality expert. Subsequently, a series of 16 tapes on the quality improvement philosophy and techniques of Joseph Juran, another leading quality expert, was shown to all exempt employees within M&C, with classes taught by senior and operating management. Managers and operating personnel were also trained in quality tools such as control charts and statis-

tical process control. The classes helped to instill awareness and to communicate the corporate commitment to quality improvement.

A quality reporting system was implemented to supplement TI's extensive system of financial indicators. For years, TI had evaluated the profit-and-loss performance of each business with a series of financial indices published each month in the "Blue Book." In 1981, TI began a "Quality Blue Book," with indices such as product reliability, customer feedback regarding TI quality, and data on the cost of quality. The Blue Book format was deliberately chosen to communicate to TI managers that quality performance was now to be judged on the same level as financial performance.

Quality Blue Book

Like its financial counterpart, the Quality Blue Book contained three pages of indices presenting actuals versus goals, previous period comparisons, and three-month forecasts. Unlike the highly structured financial Blue Book, however, the Quality Blue Book performance indices were generally determined by the responsible PCC manager. This assignment allowed managers to tailor the report to reflect the key quality indicators in each business. Performance indicators for Motor Controls, a typical PCC, are defined in Exhibit 1.

Cost of Quality

Cost of quality (COQ) was one of the performance measures that had to be included in every business unit's Quality Blue Book. COQ represented expenditures that arose because poor quality had occurred or to prevent poor quality from occurring. The COQ measure was designed to highlight the cost of poor quality, the cost of doing things wrong. Explained J. Fred Bucy, TI's president and chief operating officer, in a statement to the company's employees:

> Some people think that quality costs money, because they see the costs of quality in terms of new testing equipment, added inspectors, and so on. But those are the costs of doing it wrong the first time. If we design a product right the first time, and build it right the first time, we save all the costs of redesign, rework, scrap, retesting, maintenance, repair, warranty work, etc.
>
> Consider how much of your time is spent in doing something over again. How much of your assets are tied up in rework, retesting, repair, and making scrap? How much material is wasted at TI? If we could eliminate these costs by doing things right the first time, we would have true People and Asset Effectiveness, and improved profitability, without having to add a dollar to billings.

The cost of quality system was a key component of the Total Quality Thrust. By measuring quality in financial terms, the COQ system allowed M&C management to create a major cultural change by using a term familiar to everyone—the bottom line. Tom Haggar, Controller of the Metallurgical Materials Division, observed:

> COQ ties quality progress into what we're here for—to be a profitable world-class manufacturer constantly improving quality. COQ numbers shocked PCC managers. We initially showed them COQ figures of 10%: 10% of sales value, and an even greater percentage of profits, down the hole. It is now down to a less shocking 4–5%. Managers are saying that they haven't found all of the costs but that the trend is right. Even today's lower percentage is not making them comfortable. A cultural change was needed from the old to the new. For example, we used to budget for 5% scrap, but no longer. We now recognize that budgeting for bad-quality production is ridiculous.

Implementation of the COQ system began in the fourth quarter of 1981 when the Quality Department undertook a quick top-down exercise to determine quality costs. By the following quarter, an ongoing system based on accounting data was in place. At present, Control and Finance provided the PCC's Quality Department with data from the ac-

EXHIBIT 1 Quality Blue Book Performance Indicators—Motor Controls PCC

Concurrent Indicators	
Lot acceptance (%)	Percentage of lots accepted by Outgoing Quality Control. Tracked by product line.
Average outgoing quality level	Defective parts per million. Tracked by product line.
RMR% quality	Returned Merchandise Report percentage. Percentage of shipments returned from customers because of poor quality.
RMR% total	RMR% quality + percentage of shipments returned for reasons other than poor quality. These include incorrect quantity shipped, wrong parts, incorrect packaging, etc.
Customer report card	Customer lot acceptance level. A sample of customers is interviewed to get feedback on M&C quality. Lack of recordkeeping by customers limits the availability of quantified data on this indicator.
Competitive rank	Subjective self-ranking of competitiveness. Ranking is done by marketing and field sales personnel. The fraction presented in the report represents M&C's competitive ranking relative to the number of competitors in that product line.
On-time delivery	Shipment of at least 90% of the order on or before the acknowledgment date (indicator added in 1984).*
Leading Indicators	
First-pass calibration yields	Most products produced by this PCC are calibrated to open at a specified temperature. After processing, 100% of the units are tested either manually or automatically to determine that the units were calibrated correctly. This indicator reflects the percentage of units that pass this inspection.
Cost of quality	Calculated as the percentage of quality costs to net sales billed. Quality costs are defined as costs that incurred due to poor quality or to prevent poor quality from occurring.

**Some debate existed as to whether "on-time delivery" represented a quality indicator to be put in the Blue Book. Only in the last quarter of 1987 did most divisions in the group incorporate this measure. The on-time delivery percentage was calculated on events rather than dollars to ensure that shipments to smaller customers received equal weighting. The previous measure of delivery performance was whether a customer was ever forced to shut down, ignoring instances in which customers were forced to reschedule production due to late delivery. In 1981, on-time delivery was less than 50%. By 1987, 97% of the 2,000 shipments per week were delivered on time.*

counting system on the sixth working day following the close of the month. The Quality Department then processed this information into the Quality Blue Book.

The initial list of COQ variables included 77 items, a number that had since been reduced to 19 through the elimination of semantic overlaps between divisions and the merger of nonsignificant categories into other cost elements. The variables were grouped into four broad categories:

1. Prevention costs: Costs incurred to prevent nonconforming units from being produced
2. Appraisal costs: Costs incurred to ensure that materials and products that failed to meet quality standards were identified prior to shipment
3. Internal failure costs: Scrap costs and costs incurred in correcting errors caught at appraisal, before delivery of the product to the customer
4. External failure costs: Costs incurred in correcting errors after delivery of the product to the customer

The variables included in each category differed somewhat among PCCs, depending upon the nature of the business. The cost elements utilized by the Motor Controls PCC are shown in Exhibit 2.

EXHIBIT 2 Cost of Quality Variables—Motor Controls PCC

Prevention Costs	
Quality engineering	Total quality engineering expense from the monthly actuals report.
Receiving inspection	Total receiving inspection expense from the monthly actuals report.
Equipment repair/maintenance	Estimated percentage of actual repair and maintenance expenses spent on preventive maintenance. (An estimate of 15% of total R&M expenses was developed by PCC management in 1981. This percentage had not been revised since the original estimate was made.)
Manufacturing engineering	Estimated percentage of actual manufacturing engineering expenses spent on prevention. The estimated percentage is revised every six months by the manager of manufacturing engineering.
Design engineering	Estimated percentage of actual design engineering expenses spent on prevention. The estimated percentage is revised every six months by the manager of design engineering.
Quality training	Actual cost of quality training from the labor reporting system. Quality training time is charged to a special labor link (charge) number.
Appraisal Costs	
TSL laboratory	Total technical services laboratory expense from the monthly actual report. The Technical Services Laboratory is responsible for sophisticated quality-related testing.
Design analysis	Estimated percentage of actual design analysis expenses spent on appraisal. The percentage is revised every six months by the manager of design analysis.
Product acceptance	Total inspection (quality control) expenses from the monthly actuals report.
Manufacturing inspection	Actual cost of manufacturing inspection from the labor reporting system. Manufacturing inspection is charged to a special link (charge) number.
Internal Failure Costs*	
Quality scrap	Calculated as [(material issued at standard) − (material scheduled for production at standard)] multiplied by a labor and overhead factor. The labor and overhead factor represents the amount of labor and overhead costs incurred in the assembly prior to its scrapping.† Obsolete parts scrapped out of inventory are not included in this measure.
Rework	Actual cost of rework from the labor reporting system. Rework is charged to a special link (charge) number.
Manufacturing/process engineering	Estimated percentage of actual manufacturing/process engineering expenses spent on internal failure. The estimated percentage is revised every six months by the manager of manufacturing engineering.
External Failure Costs	
Net RMR* cost marketing	Cost of returns less good material to inventory.‡ Estimated percentage of actual marketing expenses spent on external failure. The estimated percentage is revised every six months by the marketing manager.
Manufacturing/process engineering	Estimated percentage of actual manufacturing/process engineering expenses spent on external failure. The estimated percentage is revised every six months by the manager of manufacturing engineering.
Repair	Actual cost of repair from the labor reporting system. Repair time is charged to a special link (charge) number.
Travel	Actual travel costs related to quality problems. Computed from the monthly actual report.

continued

Liability claims	Infrequent claims. Liability claims are included when incurred or when a reserve is taken. Legal fees, which are not on the Group profit-and-loss statement, are not included.

**Internal failure and net RMR costs are available at the product line level. All other elements are captured at the product (PCC) department level.*

†In 1981, a study was conducted to determine at which point in the assembly process products were being scrapped. As a result of this study, a factor of 88% above scrapped material costs was calculated to account for labor and overhead. This factor had not been changed since the original study.

‡If a $5 product was returned due to defects, it could either be scrapped or reworked and returned to inventory. If the item were scrapped, the net RMR cost would be $5. If, on the other hand, the item were reworked at a cost of $1, rework costs of $1 would be reported and no costs would be included in net RMR.

Several categories of quality costs, such as indirect costs and losses considered inherent to the manufacturing process, were not captured in the COQ system. Indirect quality costs arose when support department personnel repeated tasks because of problems with shipments (defective or incorrect parts, over- or undershipments, late deliveries, etc.) or because the tasks were not done correctly the first time. Examples included the cost of retyping orders, rebuilding tools, and rebilling customers as well as correcting paperwork errors and incorrect journal entries. Efforts were under way to determine the level of indirect quality costs through "Hidden Factory" reviews.

When originally implemented, the COQ system excluded costs that were considered to be a standard part of the manufacturing process. For example, a calibration process in production may have been imperfect, requiring parts to be manually checked on the line. The costs of the manual checking were not included in COQ, leading to an understatement of quality costs. Scrap costs were also underreported by a number of PCCs. The PCC managers argued that "engineered scrap," such as the material left when a round part was punched out of a square piece of metal, was inherent to the process.

The COQ system had been easy to implement since it used data that already existed in the accounting system. Now, however, the desire to maintain consistency over time, so that trends would be visible, had made it difficult to add new measures such as indirect quality or engineered scrap costs. In effect, attempts to update the COQ system to make it more accurate and relevant were in conflict with the need to maintain comparability across periods.

Uses of COQ Data

Initially, the COQ system was resented as just another number to be judged against. Carl Sheffer, General Manager of the Motor Controls PCC, recalled his concern: "I resented the system, feeling that quality was a virtue in its own right. Attempting to assign costs to quality diminished its value. Value is not in the numbers but in the areas they represent."

By 1987, however, the quality indicators and the COQ data in the Blue Book had become widely utilized management tools at M&C. Two factors had contributed to the system's widespread acceptance. First, quarterly financial forecast reviews were supplemented by quality reviews. PCC managers were now allowed to present the results of operations in a less structured format with emphasis on the areas of importance to each business.

Second, the Quality Blue Book was not used to "hammer" the PCC managers. Perfor-

mance was not measured exclusively on the achievement of quality goals, nor were quality measures compared across businesses. Rather, the quality measures were used to focus on long-term trends of quality improvement and to highlight potential sources of quality problems.

The Quality Blue Book was distributed to the group president, controller, vice president of People and Asset Effectiveness, and to the responsible division and PCC managers on a monthly basis. Although not formally distributed to operating personnel, the information was widely available to them. Jim Meehan, PCC Quality Manager, noted:

> I don't distribute Quality Blue books to anyone below the level of the PCC manager. The PCC manager must take responsibility for getting copies to all the operating functions. Everybody probably sees them, and anyone who asks me can have a copy. Different people use different measures—the PCCs use Cost of Quality, manufacturing uses internal failures, operations is interested in on-time delivery, and marketing wants to know about external failures.

Carl Sheffer discussed his use of the data:

> The reports go to all of my managers and team members. I take personal interest in Cost of Quality and ask for the numbers. At monthly meetings, the COQ numbers are discussed with the nonexempt employees. I highlight product lines that have improved and lines that have deteriorated. We primarily focus on Internal Failure and RMR [Returned Merchandise Report] because they are "hard" numbers. The others are more helpful for trends.
>
> This year, the Cost of Quality numbers provided the single best indicator that problems had arisen in production, problems that had caused a bad P&L performance. The Cost of Quality showed deterioration in internal failure when the department claimed that scrap rates were down. The discrepancy arose from the department's not realizing that it had not reduced the amount of overage (material in excess of the minimum required) issued from the stockroom. Eventually, a physical inventory check found unused material all around the shop. So, the Cost of Quality report signaled a problem that may have gone undiscovered for a while.

In addition to Quality Blue Book reports, Sheffer had developed special COQ reports for his area (see Exhibits 3–5). Problems reflected in the COQ reports were not always indicative of actual quality shortcomings, however. Continued Sheffer:

> A couple of years ago, we saw continually worsening trends in the Cost of Quality. After investigating, we found that the selling price had been reduced 10%. The same scrap rate led to the Cost of Quality, measured as a percent of net sales billed, to go way up. This is a profitability problem but not one caused by a quality problem.

EXHIBIT 3 Product Line Failure Costs—Motor Controls PCC

PRODUCT A	SEP	OCT	NOV	YTD 1987
Activity $	$522,833	$467,380	$424,051	$5,398,635
Internal Failure COQ $	14,637	28,597	2,170	232,221
External Failure COQ $	425	0	85	4,420
Total Failure COQ $	15,062	28,597	2,255	236,641
Non-Conformance COQ %	2.88%	6.12%	0.53%	4.38%
Variance Prior Year %	0.38%	−2.86%	2.73%	−1.12%
Variance Prior Year $	$1,982	($13,361)	$11,569	($60,645)
Cumulative $	($58,853)	($72,214)	($60,645)	

EXHIBIT 4 Failure Rates by Product—Motor Controls PCC

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
Product A													
Overage %	7.1%	8.7%	10.6%	11.5%	8.9%	1.7%	7.1%	−2.1%	15.8%	3.7%	4.4%	—	7.1%
Internal failure	7031	8973	13548	11278	8310	2474	7031	−1595	15341	3995	5914	—	82300
External failure	2805	3740	1020	0	340	0	85	8670	0	0	0	—	16660
COQ %	5.6%	5.3%	5.6%	4.4%	3.5%	0.9%	5.1%	3.6%	7.3%	1.8%	2.8%	—	4.1%
Product B													
Overage %	3.6%	4.0%	5.7%	4.2%	2.9%	3.7%	7.6%	1.2%	2.6%	3.7%	−8.5%	—	2.3%
Internal failure	932	874	1506	1393	1107	1045	1523	600	1255	1543	−2894	—	8884
External failure	0	0	0	0	0	0	0	0	0	0	0	—	0
COQ%	2.8%	4.1%	4.6%	3.7%	2.3%	3.0%	14.2%	1.0%	2.0%	4.0%	6.6%	—	2.1%

EXHIBIT 5 Motor Controls PCC Departmental Non-Conformance Costs—YTD through November

NC SAVINGS VS. 1986*		YTD NC COQ % NSB	
Product A	$89K	Product A	1.6%
Product B	61K	Product B	2.1%
Product C	52K	Product C	3.1%
Product D	20K	Product D	3.3%
Product E	16K	Product E	3.4%
Product F	8K	Product F	3.5%
	Dept avg.		3.1%

**Represents the difference between actual 1987 quality costs and the quality costs that would have been incurred at the 1986 COQ percentage. Includes internal and external failure costs only.*

COQ Projects

Quality improvements were aided by management's willingness to expend funds on projects that produced intangible benefits, such as quality and service, without rigorous financial justification. Concurrent with the financial planning cycle, quality improvement teams, consisting of department managers, their staff, and representatives of support organizations such as marketing, engineering, manufacturing, production control, quality, finance, and purchasing, met to establish Cost of Quality improvement projects, using COQ system numbers as priority-setting mechanisms. Anticipated savings from the COQ improvement projects were estimated and incorporated into the product line's profit forecast. COQ savings by project were subsequently tracked by the manufacturing engineering department (see Exhibit 6). Bob Porter, Vice President of Quality Assurance and Reliability, felt that the identification and implementation of COQ projects were the keys to instilling quality awareness and improving quality performance within the group:

> The critical issue is the "process." By that I mean getting management involved in identifying opportunities for quality improvement, establishing priorities, helping ensure that resources are available, and monitoring progress. We need to speak the right language on each of these issues, and COQ is the language of management.
>
> Two of the organizational mechanisms that support the process are the quality improvement teams (QIT) and the People and Asset Effectiveness (P&AE) reviews. The QITs, which are in place at the group, division, and department levels of the business, consist of natural work groups of managers and professionals who meet regularly to steer the quality excellence process. The quality (P&AE) reviews, which are held quarterly, are

EXHIBIT 6 Motor Controls PCC Cost of Quality Project Savings—1987 Cost Reductions ($K)

COQ PROJECTS	1Q	2Q	3Q	4Q	YR87	VARIANCE FROM ANNUAL PLAN
Yield improvement	26	61	55	54	196	150
Upgrade assy machine	20	24	32	44	120	53
Redesign molded part	16	20	24	53	113	(55)
Non-destruct testing	10	11	14	17	52	13
Laser coding	9	10	9	10	38	30
Flash reduction	8	9	11	10	38	22
Stat. process contl.	93	119	128	127	467	(90)
Total	182	254	273	315	1024	123

high-level management reviews in which business managers review progress against their short- and long-term quality goals.

Early in the year, the lowest-level QITs identify quality improvement opportunities. Frequently, senior management attends these department QITs, where the champions of these projects discuss the opportunities. These projects are dollarized, time-phased, assigned champions, and summarized at the division level. The forecasted COQ savings are recognized in the annual plan. Key COQ projects are summarized at the group level. The COQ trend is tracked and reviewed at every group and division QIT meeting.

At the P&AE reviews, the operating departments discuss their short- and long-term goals. Much of this is focused on the progress of key COQ projects—how the QITs are using quality tools such as statistical process control to drive continuous improvement in COQ. This process is not treated as an exact science. It is not preoccupied with testing the validity of the numbers or comparison of one entity versus another. It is focused on who, what, and when, and closing the loop on results.

In summary, the operating businesses have ownership. They establish priorities and wrestle with the resource tradeoffs. The quality organization provides lots of support, but quality improvement is clearly not a program of the quality organization. Operations managers work to achieve goals they helped to establish. Progress is monitored against milestones throughout the year at the QITs and P&AE reviews.

If this process works well, the COQ numbers will take care of themselves. Without the COQ numbers, however, this process wouldn't work.

System Results

Between the formal inception of the COQ system in 1982 and the end of 1987, Cost of Quality as a percent of net sales billed had fallen from 10.7% to 7.8%. Reductions had occurred in each category of quality costs (see Exhibit 7). The system had also focused increased attention on the impact of improved quality on costs and profitability. Carl Sheffer, though, still had mixed feelings about the current COQ system:

> Motivating senior management wasn't a problem. They already knew that quality was critical. COQ was most helpful for middle managers to see the consequences of poor quality on overall income. COQ gives one number that focuses several things together. If we focused just on scrap, we would get lower scrap costs but would go out of business as we passed scrap on to the customer. On the other hand, if we tried to focus on reducing external failures through inspection alone, without actually reducing manufactured defects, we would become uncompetitive cost-wise. COQ forces us to think about an optimum relationship among the various factors. You have to improve the whole, not pieces at a time.
>
> The COQ system has proven to be a good attention getter, has forced priority setting, and has stimulated quality improvement activities. It also ends up being a good scorecard. It does much less well as a diagnostic tool, partially because it uses accounting techniques. It is sometimes difficult to find out what the problem is without supplementary diagnostic tools.

EXHIBIT 7 Cost of Quality, % of Net Sales Billed—Materials & Controls Group

	1982	1983	1984	1985	1986	1987
Prevention	2.3	2.0	2.0	2.1	2.3	2.3
Appraisal	2.2	1.9	1.7	1.9	1.9	1.8
Internal failure	5.3	4.8	4.5	4.2	3.6	3.3
External failure	0.9	0.7	0.6	0.4	0.4	0.4
Total COQ	10.7	9.4	8.8	8.6	8.2	7.8

> Maybe the things we track well, such as internal failure, should be reported more often, while COQ in general could be done less frequently. Indirect cost of quality tracking probably doesn't need to be continuous. We should look at each function and ask "Why does it exist?" If the function only exists to correct errors, we can probably eliminate it. Getting rid of the function will be more appropriate than tracking secretary time, paper processing, cost of calling customers, etc. We need to focus on the big items.

The Future

As 1987 came to a close, Werner Schuele, Vice President of People and Asset Effectiveness, was evaluating potential changes to the Cost of Quality system as part of an overall company review of its cost systems. Although the COQ system remained a valuable tool to highlight quality trends, allocate resources, and instill quality awareness, Schuele was not sure that COQ could continue to drive improvements in quality unless improvements were made. He felt strongly that the costs tracked by the system were only 50% of actual quality costs, resulting in inadequate attention being focused on major sources of quality costs. But he also knew that changes to the system might distort trends in the data, perhaps the most valuable use of the information. Schuele felt some reticence in implementing an indirect quality cost tracking system:

> I would love to track it if I knew how. We could avoid the trend distortion issue just by having just two categories: direct and total (i.e., direct and indirect). My major concern is that determining the real cost of "indirect scrap" is not precise and has no foundation in our accounting system. For example, nowhere is the cost of retyping a letter with a misspelled word tracked. My dilemma is that I'm not sure that the cost of developing the tracking system is worth it. Also, there is no organizational mandate to develop a precise indirect system.

Finally, Schuele was not convinced that monthly COQ reporting was necessary. Over the next six months these questions would need to be addressed and recommendations presented.