The Human Factor
What Sets Quality Leaders in Manufacturing Apart
The Boston Consulting Group (BCG) is a global management consulting firm and the world’s leading advisor on business strategy. We partner with clients from the private, public, and not-for-profit sectors in all regions to identify their highest-value opportunities, address their most critical challenges, and transform their enterprises. Our customized approach combines deep insight into the dynamics of companies and markets with close collaboration at all levels of the client organization. This ensures that our clients achieve sustainable competitive advantage, build more capable organizations, and secure lasting results. Founded in 1963, BCG is a private company with 77 offices in 42 countries. For more information, please visit bcg.com.
The Human Factor

What Sets Quality Leaders in Manufacturing Apart

Daniel Spindelndreier and Frank Lesmeister
The Boston Consulting Group

Robert Schmitt, Helmut Lieb, and Alexander Linder
Laboratory for Machine Tools and Production Engineering, RWTH Aachen University

August 2012
In a world of increasing product complexity and rising customer expectations, high quality is more of a competitive advantage than ever. How should companies seeking an edge focus their efforts? A wide-ranging study of best practices in manufacturing quality management points to the primacy of people.

**The Three Dimensions of Quality**
Best-practice companies enjoy strong governance, implement robust processes that span the value chain, and recognize that the most important resource is a well-trained and deeply engaged workforce.

**Creating a Quality Culture**
Leading companies see failures as opportunities for improvement. Reporting of problems is encouraged, and operators feel fully responsible for quality. Management accepts that failures will occur—and asks questions if none are reported.

**The Journey to Superior Quality**
The cultural foundation comes first, and creating it is very much a top-down exercise. Top management has to become a role model, visible on the shop floor and demonstrating commitment at every opportunity.
The last decade has been an especially active period in the long-running quest for quality in manufacturing. As products get more complex and customer expectations continue to rise, the competitive advantage enjoyed by quality leaders increases apace. Manufacturing companies have responded by embracing the most sophisticated approaches available—developing quality management systems, taking up quality management tools, and implementing standardized quality processes. These efforts have yielded big improvements in sectors ranging from autos to pharmaceuticals to information technology and beyond.

Yet quality problems still appear, sometimes in dramatic fashion. Johnson & Johnson last year agreed to place three plants that manufacture over-the-counter pain and allergy medications under the supervision of the U.S. Food and Drug Administration because of quality issues. Toyota, a longtime leader in quality management, announced a global recall of 1.5 million passenger cars in 2010 because of brake and fuel pump problems. Many more companies have experienced lesser setbacks of one kind or another.

Are such events inevitable, even after all the money and effort companies have put into quality management? The answer, happily, is no. Though perfection will doubtless remain out of reach, quality management itself can benefit from continuous improvement, just as products and manufacturing processes can.

In that spirit, The Boston Consulting Group recently collaborated on a major study of best practices in quality management. We learned a number of lessons, but one stands out for being fundamental to success, regardless of industry, region, or company size—and for being as challenging to act on as it is easy to grasp. And that is the primacy of people in quality management. Although the discipline frames its goals in engineering terms, it can only achieve them by getting the human and cultural factors right throughout the organization, from a strong management team that puts quality at the top of the agenda to quality-minded line operators who are constantly trying to optimize processes within their working areas.

Learning from the Leaders
The goal of our study was to identify the drivers of sustainable high quality. What are the most successful companies doing differently from the rest? Our research partner was the Laboratory for Machine Tools and Production Engineering at RWTH Aachen University, a European leader in the field of quality management. The heart of the project was a survey of more than 150 manufacturing companies...
in Germany, France, Scandinavia, the U.S., Canada, India, and China operating in a range of sectors including industrial goods, consumer goods, pharmaceuticals, technology, and automotive. We augmented the results of the survey (which covered manufacturing, R&D, and procurement topics) with more than 25 personal interviews, as well as our combined experience in the field.

As expected, the companies in our survey are making good use of the modern quality-management tool kit. Quality improvement programs have been a major focus. In the last five years, 47 percent launched Six Sigma programs, 43 percent launched zero-defect programs, 83 percent launched continuous-improvement programs, and 73 percent launched lean-manufacturing programs, with a majority in each case saying they were either satisfied or very satisfied with the results. Continuous improvement and lean manufacturing are particularly effective drivers of improved quality, the survey showed.

But on a deeper level, what our research points to are the human factors that enable the top-performing companies to get the most out of the programs and tools they employ. Success with continuous improvement, for example, depends heavily on an ability to elicit and act on employee ideas. Human factors also underlie the power of most lean-manufacturing principles to improve quality, in addition to their positive impact on productivity, costs, capital intensity, and lead times. Standardization, for instance, improves lead times and quality by stabilizing the outcome of process steps. If standard procedures are always followed when workers identify problems, standardization also becomes a lever for continuous improvement—and a tool for helping the company gain the edge that goes to quality leaders.

The Three Dimensions of Quality

Our study took a holistic view of quality management, one that extends well beyond the shop floor to include company leaders, suppliers, and customers—all of whom play a role in enabling companies to produce high-quality products that meet customer requirements for functionality and cost, are free from defects, and are delivered on time. To capture the full scope of quality management, we used a framework (illustrated in Exhibit 1) that looks at three distinct but interrelated dimensions:

- **Governance.** Quality starts at the top, with leaders who set goals based on business strategy, communicate those goals energetically, and monitor performance at all levels of the organization. Good governance includes clearly defined roles and responsibilities relating to quality, with guidelines and processes described in a lean and user-friendly quality-management system. At top-performing companies, governance engenders a strong quality culture, with every employee understanding the importance of quality and working to improve it.

- **The Quality Stream.** Driven by the operational functions of quality management, the quality stream comprises all the quality processes across the value chain, from R&D to sales. It is where the guidelines set in the governance process are applied. What differentiates the top performers here is that, along with running their processes extremely well, they have established robust cross-functional feedback loops. These tight lines of communication along the
value chain enable the continuous improvement of products and processes—a vital part of any program, since achieving the highest quality from scratch is not possible.

- **Resources and Services.** At a minimum, the resources needed to run the quality processes and keep the quality stream flowing efficiently include a solid infrastructure and highly capable machines, in addition to effective quality-management tools. But the resource that sets quality leaders apart is a highly trained and engaged workforce guided by a clear understanding of how the tools and processes are meant to work and what the quality goals are.

Not surprisingly, the most successful companies are the ones that excel on all three dimensions. We identified two levels of capability in each: table stakes, which are the minimum requirements a manufacturer must meet to stay in the game, and differentiators, found at companies that enjoy a competitive advantage by virtue of their quality-management capabilities. (See Exhibit 2.) Human and cultural factors make up a significant portion of the table stakes. When we look at the differentiators, though, human and cultural factors—from the use of kaizen teams to cross-functional feedback loops to individualized training and personal communication of targets and performance—dominate the list.

The companies that employ these best practices enjoy a significant advantage over their lower-quality competitors. (See the sidebar, “Quality Pays.”) It’s not an edge they achieved overnight. They have typically traveled a journey that began, as it must, with a commitment by management to make quality a part of the business strategy. As we will show, it’s a journey that other companies can make as well and for which our framework can serve as a useful guide. But first, let’s take a deeper look at what’s making the quality leaders in our study successful on each of the three dimensions.

**EXHIBIT 1 | Quality Management Has Three Dimensions**

![Diagram](https://example.com/diagram.png)

Source: Laboratory for Machine Tools and Production Engineering, RWTH Aachen University, and BCG analysis.
Governance: Creating a Quality Culture

Perhaps the most underappreciated element of a successful quality-management effort is the psychological one. In our survey, the most commonly cited driver of high quality was a strong quality culture, also described as a continuous-improvement culture. And at top-performing companies, we found that the defining trait in this kind of culture is the recognition that failures are opportunities for improvement. Identification and reporting of quality problems are encouraged; operators feel fully responsible for quality processes and are engaged in improving them. Management accepts that failures will occur and asks questions if none are reported.

Though it sounds simple, many companies struggle to find the governance levers that will enable them to move the organization in this direction. Our study identified three important ones:

- **Management Focus.** A commitment to quality in the company’s vision or mission statement is important—but words aren’t nearly enough. At the best-performing companies, top managers serve as role models. Quality always ranks high on their agenda and is a standard topic at management meetings. Managers frequently visit the shop floor and discuss quality issues with operators and line managers. Plant leaders are on the shop floor every day and corporate manufacturing leaders visit sites at least once a week, reminding employees of the importance of their work and increasing their awareness of quality. This kind of
Quality pays

Quality comes at a price, payable in time, money, or both. So says manufacturing’s “magic triangle,” which illustrates the tradeoffs among high quality, low costs, and speed, and asserts the need to choose and set priorities. But our experience shows that this is true only at the simplest level.

Of course, achieving superior quality requires resources; it costs money and can also increase lead times, especially in development. But a closer look at the impact of good (and poor) quality shows how a company’s investment in superior quality can pay significant financial rewards.

Quality is best understood as the ability to meet customer requirements. That means delivering what the customer considers to be the right product at the right time at the right cost. Quality management isn’t only about reducing and preventing failures. Just as important, it is about creating products and services that reflect a deep understanding of customer needs—and that therefore have considerable power to boost sales.

Poor quality raises costs and creates negative ripple effects all along the value chain. A company that has to identify failures through controls must devote a lot of resources to quality assurance. Preventive quality management, by contrast, leads to more stable processes and therefore to fewer required controls. Failures raise costs by creating scrap and necessitating rework and the production of additional parts to replace substandard ones. Preventive quality management will reduce failures and the resulting costs. Low quality in R&D will cause costly problems in production. Unstable production processes will lengthen lead times, which will lengthen delivery times, which will reduce customer satisfaction—with a direct impact on sales volume. We could add more points to this list, but the bottom line is this: by raising quality, you can lower costs and shorten lead times.

Our experience shows that companies with superior quality can outperform companies with poor quality by two to three times based on return on sales, and by up to five times based on sales growth. Quality leaders can achieve a scrap rate that is only 30 percent of the rate suffered by companies with lower quality. Consider the case of a company with $500 million in sales, a margin of 5 percent, and a scrap rate of 3 percent. With better quality management, this company could increase its profit by $9 million to $10 million. We have also found that companies can reduce R&D expenses by 20 to 30 percent by focusing more on predevelopment and using preventive quality-management tools like failure mode and effect analysis and quality function deployment.

Must a company have a lot of quality specialists on staff to get these kinds of results? The answer is no. Analyses show that companies with good quality processes in place often have fewer people working in quality than low-quality companies. The main reason is that a focus on preventive quality management is more efficient than failure correction and control. After all, an ounce of prevention is worth a pound of cure.
focus is especially associated with Japanese companies, but it’s found elsewhere as well. At a European aluminum producer, for example, the technical director spends more than 50 percent of his time on the shop floor and is seen by his employees in the factory at least once a day.

- **Employee Suggestion Process.** Nearly every company in the study has some kind of employee suggestion process in place, meant to increase motivation and leverage employees’ experience. But not every company is satisfied with the results. A functioning process has two key elements: a scheme for rewarding good ideas and a transparent and efficient system for evaluating suggestions, since nothing is more frustrating for employees than getting no feedback, especially about why a proposal was rejected. But these are just table stakes. The top-performing companies take the communication further, welcoming critical thinking from the shop floor at every level of the organization. Their heightened ability to integrate the shop floor’s expert knowledge into processes and motivate employees to generate ideas can be a real differentiator.

- **Cross-Functional Kaizen Teams.** Having employees participate directly in quality improvement projects is the single most effective thing companies can do to send the message that quality products and processes are important, and that employees play a significant role in achieving them. Most of the companies in our study use kaizen teams, with the best-performing ones often conducting kaizen events as add-ons to an employee suggestion process. But the real differentiator is the use of teams that include representatives from multiple departments and functions, including up- and downstream process steps. Cross-functional teams can go beyond incremental improvements in one department to have an impact on the company as a whole.

One Japanese electronics manufacturer uses cross-functional teams in a particularly effective way. Along with the more routine bottom-up, or operator-level, kaizens, the company convenes top-down kaizens every six months, gathering representatives from different departments (such as production areas, R&D, and procurement) and assigning them clear targets, typically step changes in quality or performance. Participants are largely freed from their daily responsibilities to carry out the assignments, which usually take two or three weeks to complete.

Implementing kaizen teams requires a significant commitment of resources, mainly in the form of employee time. Companies also must recognize that not every initiative will produce a direct payback. But participating in the teams helps employees develop an obsession with solving problems—a key ingredient in a quality culture.

The importance of fostering a strong quality culture is hard to overstate. Another Japanese company, a motorcycle manufacturer, has developed one of the strongest we’ve seen and has benefited greatly. Training and development of staff are major priorities for this company, as is maintaining a good working atmosphere. Employees show a clear passion for their work and an ongoing commitment to improving products and processes. In operator-driven kaizen activities, for example, workers
developed a series of simple but effective tools like *poka-yokes* that increased first-pass yield significantly and reduced lead times by more than 40 percent.

**The Quality Stream: Operational Excellence and Feedback**

Good governance can make quality a shared goal, but actually producing products with high and stable quality requires effective processes up and down the value chain. These processes are the heart of quality management, and the companies in our survey use a wide array of them. Standardization, for example, is employed in production, R&D, and procurement by the majority of companies. But success with standardization is a table stake, not a differentiator. What differentiates the quality stream operations of the top performers? Along with overall operational excellence, our research points to proficiency in two particularly challenging processes combined with cross-functional feedback loops. We’ll look at each one in turn.

**Line Stops.** More than a quarter of the companies in our survey reported using line stops, meaning they will stop a production line if a failure occurs and restart it only after fixing the problem. If the failure isn’t just a one-time event, best practice calls for the root cause to be analyzed in detail and eliminated before production is resumed.

In our experience, however, line stops aren’t always used in a sufficiently stringent way. Often, products are reworked within the line, parallel to the line, or at the end of the process. Rigorous root-cause analysis of recurrent failures—using approaches like the 5 Whys or Ishikawa diagrams—is in fact extremely rare. Time and cost pressures are usually the reason, and it’s true that line stops with root cause analysis require a significant effort. But it’s also true that they prevent failures and significantly reduce costs in the medium term.

A best-practice approach to line stops can be found at one of Japan’s major car manufacturers. Part of the challenge in applying stringent standards lies in managing the decision process for root cause analysis once a failure occurs. Here, the automaker has developed an easy and pragmatic escalation process that requires only a simple yes or no answer at each level. At the lowest level, the operator reports the problem to the team leader, who evaluates whether it can be fixed within a *takt* time or should instead be marked and fixed at the end of the line. In the case of a recurrent critical issue—typically identified by checking the previous and next products on the line—the decision rises to the top managers, who can stop the line until the underlying root case is eliminated.

**Quality Gates.** These are control points with defined criteria that a product must meet before it can proceed to the next step. The merger of Renault and Nissan shows the power of quality gates, and also how to get more out of them. Before the merger, the two companies favored different quality-management processes. Renault focused on operator self-inspection, whereas Nissan had quality gates in place operated by an operator (“check man”) fully dedicated to this task—a more effective approach that is now also implemented at Renault. We believe, however, that a combination of the two approaches can best leverage the benefits of each. Operator self-inspection increases awareness of quality and helps identify issues as early as possible, while quality gates ensure the delivery of only failure-free parts to internal and external customers.
Quality gates in production lines must meet their own set of criteria to be effective. Testing procedures must be standardized, with quality requirements well understood by every employee. At the same time, the tests as well as the positioning of the gates must remain flexible, so they can be adapted to address problems as they occur. In cases of critical failure, combining quality gates with line stops can be very effective. This flexibility is a big differentiator. Though most companies have implemented quality gates in production, they are too often static.

Quality gates are also used in R&D by most of the companies we surveyed. In some industries (such as chemicals and automotive) they are standard. Here we often see the same weakness that undermines line stops at many companies, with time pressure leading to shortcuts. Ask yourself how often production of a new product is postponed because it doesn’t meet quality gate requirements in R&D. The price is often paid in production, in the form of a heavy quality-assurance burden. Moreover, if products are not designed for manufacturing, they often require more handling, creating quality problems and raising costs. Yet another well-known problem is that quality gates are often initiated too late, after the early phases of R&D are already complete.

Here we see the close connection between operational excellence and a quality culture. If quality awareness is not high enough throughout the company, people will respond to other signals and take shortcuts where quality is concerned. Well-designed processes will lead not to the expected results, but instead to higher costs and lower customer satisfaction.

Cross-Functional Feedback Loops. The practice of gathering and sharing data across the entire value chain—from quality gates and other areas of production, as well as from R&D, procurement, and sales—is a hallmark of top-performing companies. Survey results and interviews show it to be a major differentiator and a key driver in the continuous improvement of products and processes. The most successful companies share information across functions to ensure day-to-day process improvement, facilitate new-product development, and spread best practices.

These information flows can help solve a range of problems. Consider, for example, the success of the previously mentioned Japanese car manufacturer in addressing quality issues attributable to suppliers. When a problem occurs with a particular part, the company quickly sets up a flexible quality gate within the line to check the part. The information gathered is passed along to the procurement department, which works with the supplier to solve the problem. The quality gate is then promptly removed.

Cross-functional feedback loops also enable companies to avoid many failures in the first place by making changes in production or design. Savings can be baked in during the development phase, since R&D gets information about customer requirements from sales, about problems with specific components from procurement, and about manufacturability from the production department. Data about the usage and field quality of products, gathered by customer service and through surveys, can also be tapped. Even customer complaints, often seen as undesirable feedback, are valuable inputs for process and product improvements.
Regular cross-functional meetings help drive the communication process, giving participants a forum to share experiences and add to companywide knowledge about possible issues and levers for making improvements. Best-in-class companies are able to merge feedback data from different sources into information bundles on the most important quality issues. These bundles provide the knowledge base for highly effective root-cause analyses and improvements.

Quality-minded companies work hard to improve their feedback loops. Automotive OEMs, for example, are typically very good at using a broad range of sources to gather feedback internally (for example, at quality gates), as well as externally (for example, by using field data from inspections and warranty cases). Most of them use this information to improve manufacturing processes, and some even use it to improve the design of currently produced cars. But using it to develop new products is something most have failed at so far. While cost data regarding the components and systems of an existing car have sometimes been used very effectively in the design of a next-generation product, companies have struggled to use information about risks or failures in a systematic way.

The nuclear power industry, with its stringent safety requirements, is a best-practice example of feedback loops. One nuclear manufacturer integrates the people doing maintenance at existing nuclear plants into the teams developing new plants—a very effective way of sharing information.

It isn’t just along the value chain that feedback loops can improve quality. Communication across plants or product lines with the same function allows for the detection of failures (or their clearance) based on the company’s experience. Companywide best practices serve as benchmarks; improvements where no problems previously occurred can prevent future failures.

**Resources and Services: People Matter Most**

Robust processes and a strong continuous-improvement culture are necessary attributes for quality leaders, but these still aren’t sufficient to place a company among the top performers. The organization must also devote the right resources to the task—especially human resources. At best-in-class companies, that means a serious investment in training, so that employees are both willing and able to pursue better and better quality. Our study shows that effective training programs are another important differentiator in the competition for quality.

These programs go beyond classroom sessions focused on standard technical lessons. The best training programs combine classroom work with virtual training on demand and practical training on the shop floor or in special training facilities. They focus on the individual needs of employees based on identified quality issues, and they include training in quality management tools along with technical training for daily work. The leading companies set—and meet—ambitious training goals for their employees. Targeted quality-management tools like failure mode and effects analysis, root cause analysis, and statistical process control are used by employees wherever appropriate—there is no point in always shooting with a bazooka such as Six Sigma, with its requisite deep-dive statistical analysis. Employees with a basic...
understanding of the tools are found in every functional department, with specialists available to support them as needed.

The study also showed (and our experience confirms) how essential personal communication is when it comes to mobilizing people in the cause of quality. In a change management effort at a pharmaceutical company, personal communication became one of the main drivers of significant performance improvements. Successful companies communicate quality targets and performance status with well-designed charts on information boards customized to the operators' needs—but they also rely on personal discussions with workers, usually on a daily basis, to really make an impact. These discussions boost buy-in, understanding, and participation. Without buy-in and bottom-up input, continuous improvement on the basis of failure prevention simply isn’t possible.

The Journey to Superior Quality

As we’ve shown, companies that are quality leaders employ best practices on all three dimensions of quality management. In these organizations, culture, operations, communication, and human resources are all well developed, continuously improved, and mutually supportive. But what about aspiring quality leaders—companies that currently lack these characteristics but wish to develop them? How should they proceed?

In our experience, it’s nearly impossible to move to best practices on all three dimensions at once. Typically, a company seeking to boost its quality performance needs to evolve through four stages of maturity, first establishing a cultural foundation and then taking specific actions to improve practices at each stage. (See Exhibit 3.)

At the beginner stage are companies that have made some efforts to climb the quality curve but haven’t gotten far. Many have moved in recent years to implement basic quality-management principles like standardization, 5S, and operator self-inspection, but the defined standards are not followed stringently. Detailed root-cause analysis often shows that operators are not following guidelines. Quality awareness is low, and employees persist in working their own way. Bottom-up improvement initiatives are rare, ineffective, or both.

To move to the advanced stage on the quality curve, a company must begin developing and implementing that all-important quality culture. As we have stressed, creating this culture is very much a top-down exercise. Top management has to become a role model, visible on the shop floor and demonstrating commitment at every opportunity. Quality targets must be made an important part of business strategy, and key performance indicators must be developed and applied. Intensive and personal discussions with operators on the shop floor are essential to get their buy-in. Training on quality topics must be developed and rolled out, and an effective employee-suggestion scheme with adequate rewards and efficient feedback loops has to be implemented. Last but not least, the roles and responsibilities of line functions (such as production and R&D) and quality management have to be defined. We suggest making line functions clearly re-
sponsible for the quality they generate. This is essential to a high awareness of quality.

Once a quality culture has been established, with its effectiveness assessable through audits and surveys, we recommend further increasing quality awareness through measures such as kaizen teams and training programs customized to the individual needs of employees. This third, champion, stage of maturity is also the time to optimize the many elements of the operational system. That means improving process standards, 5S, and operator self-inspection; ensuring that these standards are met; increasing and ensuring the capabilities of machines and measurement equipment; and developing a lean and user-friendly quality-management system that is available to all employees and supports them in their daily work.

It is highly effective (and highly fitting) for the company to continually evaluate its quality-maturity level, using audits based on a standardized evaluation scheme. Drawing on the best practices identified in our research, we have developed a health check for quality management, shown in Exhibit 4. It can be used very easily to evaluate the maturity level of different functions, such as production, procurement, R&D, and sales.

After a company reaches the champion stage, it can start to approach the final, best-practice, level of maturity. Here the focus is on building cross-functional feedback loops and further developing the operational system by implementing
quality gates and line stops, improving supplier development, and fostering best-practice sharing across lines and the manufacturing network.

Of course, in a deeper sense, there is never a last step. The quest for quality is ongoing, and there is always room for improvement. But superior quality does bring real rewards, both in financial terms and in the form of competitive advantage. As our research shows, some companies have learned how to reap those rewards. They have also blazed a trail that others can follow, if they are willing to put in the effort.
About the Authors

Daniel Spindelndreier is a partner and managing director in the Düsseldorf office of The Boston Consulting Group and the coleader of BCG’s manufacturing topic. You may contact him by e-mail at spindelndreier.daniel@bcg.com.

Frank Lesmeister is a principal in the firm’s Düsseldorf office and a topic expert for manufacturing. You may contact him by e-mail at lesmeister.frank@bcg.com.

Robert Schmitt is head of the Chair of Metrology and Quality Management/Laboratory for Machine Tools and Production Engineering, RWTH Aachen University. You may contact him by e-mail at r.schmitt@wzl.rwth-aachen.de.

Helmut Lieb and Alexander Linder are scientific assistants at the Chair of Metrology and Quality Management/Laboratory for Machine Tools and Production Engineering, RWTH Aachen University. You may contact them by e-mail at h.lieb@wzl.rwth-aachen.de and a.linder@wzl.rwth-aachen.de.

Acknowledgments

The authors would like to thank Katherine Andrews, Gary Callahan, Angela DiBattista, Gina Goldstein, Kenneth Klee, and Sara Strassenreiter for their contributions to the writing, editing, design, and production of this report.

For Further Contact

If you would like to discuss this report, please contact one of the authors.