18 Operations improvement

Key questions

- Why is improvement so important in operations management?
- What are the key elements of operations improvement?
- What are the broad approaches to managing improvement?
- What techniques can be used for improvement?

INTRODUCTION

Even when an operation's strategy is set, its design finalized and its deliveries planned and controlled, the operations manager's task is not finished. All operations, no matter how well managed, are capable of being improved. In fact, in recent years the emphasis amongst operations professionals has shifted markedly towards making improvement one of their main responsibilities. In this part of the book we treat improvement activities in three stages. First, this chapter looks at the elements commonly found in various improvement approaches, examines four of the more widely used approaches, shows how these approaches fit together, then illustrates some of the techniques which can be adopted to improve the operation. Second, Chapter 19 looks at improvement from another perspective, that is, how operations can improve by managing the risks of getting worse. Finally, Chapter 20 looks at how improvement activities can be organized, supported and implemented. These three stages are interrelated as shown in Figure 18.1.

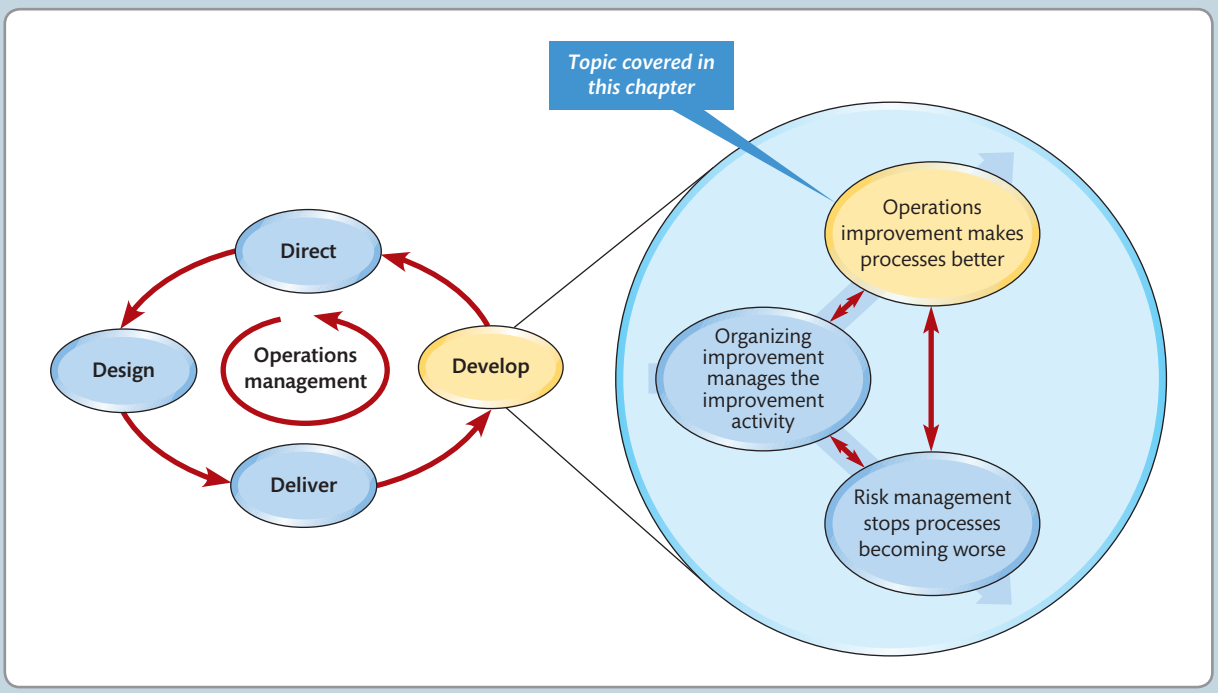

Figure 18.1 Operations improvement

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Check and improve your understanding of this chapter using self-assessment questions and a personalized study plan, a video case study, and an eText – all at www.myomlab.com.

OPERATIONS IN PRACTICE

Delivering global optimization at TNT[1]

Source: Alamy Images/Apex News and Pictures Agency

When you are in the business of express parcel delivery, operations improvement is not an option; it's a necessity if you are going to survive. Customers tend to be less than understanding if their package is late, or, worse, doesn't arrive at all. Costs, especially fuel, are on a rising curve. Competitors are getting better all the time. Setting up a global network of hubs and routes takes immense amounts of capital, and because global networks are expensive to maintain, demand has to be kept high just to break even. In addition, increasingly society expects such companies to reduce their carbon emissions. So it's a 'no brainer': delivery operations must continually be reducing costs, improving levels of service to delight customers, and deploying its resources in a manner as close to optimum as possible. This is why TNT Express started the Global Optimization Programme (known as the GO Programme) to optimize its complete logistic chain. Within this programme TNT Express aims to improve how it makes vehicle routing, hub operations, scheduling and customer service decisions all over the world by sharing best practices of the different businesses and by developing its improvement methods.

TNT Express is a package delivery service with 80,000 employees, headquartered in the Netherlands, which operates air and road networks in Europe, China, South America, the Asia-Pacific region and the Middle East. Although the company had been achieving broadly acceptable cost and service levels of performance for a number of years, by 2005 the company realized that it was not making full use of the type of analytical quantitative modelling tools that its competitors, such as Federal Express and UPS, had been using for years. It became clear that TNT Express was very late in adopting such techniques by the standards of competitor companies. Yet some parts of the company *had* been engaged in using analytical improvement tools. In Italy, TNT Express had launched its drive to optimize how it used the domestic road network to improve operational performance. Using the success in Italy as a foundation, TNT Express decided to formalize the company's improvement efforts by establishing its Global Optimization (GO) project. Just as important was the company's decision that improvement through the use of analytics must not be relegated to the sidelines as the preserve of a few specialists, but that it should be at the core of the business. However, specialist help would clearly be needed, so the company partnered with ORTEC, providers of advanced planning and optimization software solutions. With experience in providing solutions that set out to optimize the kind of activities at the heart of TNT Express's operations, such as fleet routing and dispatch, vehicle and pallet loading, workforce scheduling, delivery forecasting, and network planning, ORTEC helped provide the 'analytical muscle' needed for such complex operations.

But operations improvement is not just a matter of solving analytical puzzles; it must also engage with people in the organization. To accomplish this, the company established two people-focused initiatives called 'the GO Communities of Practice' and 'the GO-Academy'. The GO Communities of Practice was a network of individuals who had similar responsibilities, but in different parts of the world. The Community of Practice groups meet around three times a year to learn from each other's experience in applying improvement analytics in various parts of the world, with sometimes different conditions. The GO-Academy was developed to overcome some degree of resistance to the improvement initiative (not unusual with such initiatives). The objective of the academy was '*to train employees in optimization principles and, at a high level, to acquaint them with the available optimization tools, without trying to turn them into mathematicians*'. Over a two-year period participants from throughout the company have been encouraged to promote and explain the improvement initiative throughout the organization. The academy's courses are run jointly with Tilburg University in the southern part of the Netherlands.

And has all this improvement effort been worthwhile? Very much so, says TNT Express. It carried out 200 network optimization projects in one year. In the seven years after the introduction of the GO initiative, operations' decision-making quality has significantly improved and resulted in €207 million in cost savings and saved 60 million kilometres of mileage and 54 million kg of CO^2 emissions.

WHY IS IMPROVEMENT SO IMPORTANT IN OPERATIONS MANAGEMENT?

Why is operations improvement so important? Well, who doesn't want to get better? And businesses are (or should be) just the same as people – they generally want to get better. Not just for the sake of their own excellence, although that may be one factor, but mainly because improving operations performance has such an impact on what any organization is there to do. Emergency services want to reach distressed people faster and treat them better because by doing so they are fulfilling their role more effectively. Package delivery businesses like TNT Express want to deliver more reliably, at lower cost and reducing emissions because it means happier customers, higher profits and less pollution. Development charities want to target their aid and campaign for improvement in human conditions as wisely and efficiently as possible because more money will find its way to beneficiaries rather than be wasted or consumed in administration. Not surprising then that the whole emphasis of operations management has shifted towards emphasizing improvement. Operations managers are judged not only on how they meet their ongoing responsibilities of producing products and services to acceptable levels of quality, speed, dependability, flexibility, and cost, but also on how they improve the performance of the operations function overall.

✻ Operations principle

Performance improvement is the ultimate objective of operations and process management.

Why the focus on improvement?

Various reasons have been suggested to explain the shift towards a focus on improvement in professional operations managers' activities:

- There is a perceived increase in the intensity of competitive pressures (or 'value for money' in not-for-profit or public sector operations). In fact, economists argue about whether markets are really getting more competitive. As far as improvement is concerned it doesn't matter; there is a *perception* of increased competitive pressure, and certainly the owners of operations (shareholders or governments) are less likely to tolerate poor returns or value for money.
- The nature of world trade is changing. Economies such as China, India and Brazil are emerging as both producers and consumers of products and services. This has had a number of effects that have impacted more developed economies. It has introduced cost pressures in countries with relatively expensive labour and infrastructure costs; it has introduced new challenges for global companies, such as managing complex supply chains; and it has accelerated demand for resources (materials, food, energy) pushing up (or destabilizing) prices for these commodities.
- New technology has both introduced opportunities to improve operations practice and disrupt existing markets. Look at how operations in the music business have had to adapt their working practices to downloading and music streaming.
- The interest in operations improvement has resulted in the development of many new ideas and approaches to improving operations which have, in turn, focused attention on improvement. The more ways there are to improve operations, the more operations will be improved.
- The scope of operations management has widened from a subject associated largely with manufacturing to one that embraces all types of enterprise and processes in all functions of the enterprise. Because of this extended scope, operations managers have seen how they can learn from each other, even if their operations and processes seem, at first glance, different.

The Red Queen effect

In 1973 the scientist Leigh Van Valen was looking to describe a discovery that he had made while studying marine fossils. He had established that, no matter how long a family of animals had already existed, the probability that the family will become extinct is unaffected. In other words, the struggle for survival never gets easier. However well a species fits with its environment, it can never relax. The analogy that Van Valen drew came from *Alice's Adventures*

through the Looking Glass by Lewis Carroll. In the book, Alice encounters living chess pieces and, in particular, the 'Red Queen'.

> *'Well, in our country,'* said Alice, still panting a little, *'you'd generally get to somewhere else – if you ran very fast for a long time, as we've been doing'. 'A slow sort of country!'* said the Queen. *'Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!'*[2]

In many respects this is like business. Improvements and innovations may be imitated or countered by competitors. For example, in the automotive sector, the quality of most firms' products is very significantly better than it was two decades ago. This reflects the improvement in those firm's operations processes. Yet their relative competitive position has in many cases not changed. Those firms that have improved their competitive position have improved their operations performance *more than* competitors. Where improvement has simply matched that of competitors, survival has been the main benefit. The implications for operations improvement are clear. It is even more important, especially when competitors are actively improving their operations.

An important distinction in the approach taken by individual operations is that between radical or 'breakthrough' improvement, on one hand, and continuous or 'incremental' improvement on the other.

Radical or breakthrough change

Radical breakthrough improvement (or 'innovation'-based improvement, as it is sometimes called) is a philosophy that assumes that the main vehicle of improvement is major and dramatic change in the way the operation works. The introduction of a new, more efficient machine in a factory, the total redesign of a computer-based hotel reservation system, and the introduction of an improved degree programme at a university are all examples of breakthrough improvement. The impact of these improvements is relatively sudden, abrupt and represents a step change in practice (and hopefully performance). Such improvements are rarely inexpensive, usually calling for high investment of capital, often disrupting the ongoing workings of the operation, and frequently involving changes in the product/service or process technology. The bold line in Figure 18.2(a) illustrates the pattern of performance with several breakthrough improvements. The improvement pattern illustrated by the dotted line in Figure 18.2(a) is regarded by some as being more representative of what really occurs when operations rely on pure breakthrough improvement. Breakthrough improvement places a high value on creative solutions. It encourages free thinking and individualism. It is a radical philosophy insomuch as it fosters an approach to improvement which does not accept many constraints on what is possible. 'Starting with a clean sheet of paper', 'going back to first principles' and 'completely rethinking the system' are all typical breakthrough improvement principles.

✻ Operations principle

Performance improvement sometimes requires radical change.

Continuous or incremental improvement

Continuous improvement, as the name implies, adopts an approach to improving performance which assumes many small incremental improvement steps. For example, modifying the way a product is fixed to a machine to reduce changeover time, simplifying the question sequence when taking a hotel reservation, and rescheduling the assignment completion dates on a university course so as to smooth the students' workload are all examples of incremental improvements. While there is no guarantee that such small steps towards better performance will be followed by other steps, the whole philosophy of continuous improvement attempts to ensure that they will be. Continuous improvement is not concerned with promoting small improvements *per se*. It does view small improvements, however, as having one significant advantage over large ones – they can be followed relatively painlessly by other small improvements (*see* Fig. 18.2(b)). Continuous improvement is also known as kaizen. Kaizen is a Japanese

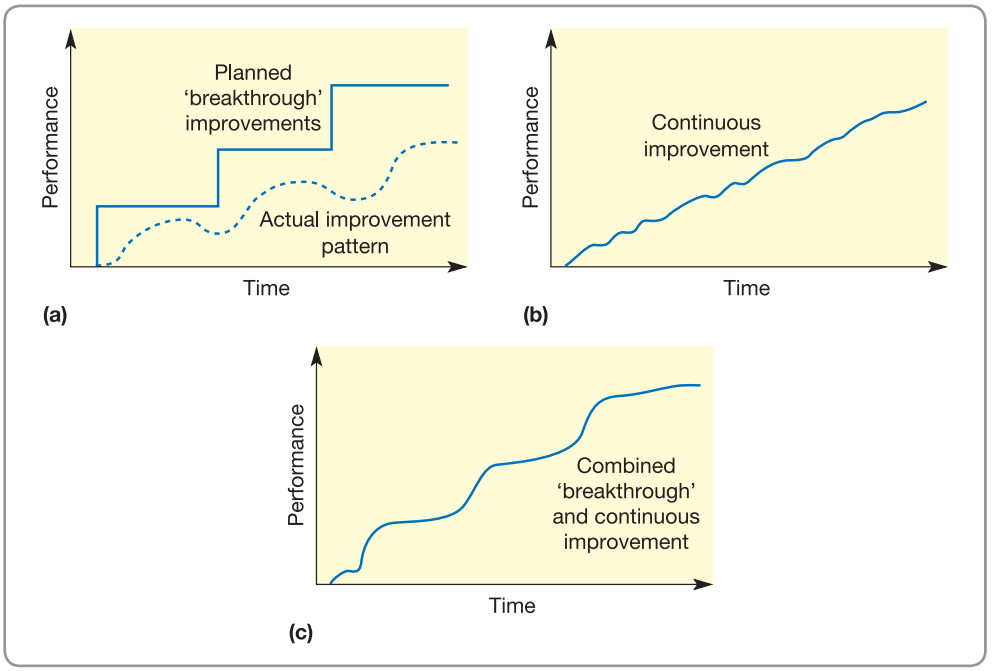

Figure 18.2 (a) 'Breakthrough' improvement, (b) 'continuous' improvement and (c) combined improvement patterns

word, the definition of which is given by Masaaki Imai[3] (who has been one of the main proponents of continuous improvement) as follows: '*Kaizen means improvement. Moreover, it means improvement in personal life, home life, social life and work life. When applied to the workplace, kaizen means continuing improvement involving everyone – managers and workers alike.*'

✻ Operations principle

Performance improvement almost always benefits from continuous improvement.

In continuous improvement it is not the *rate* of improvement which is important; it is the *momentum* of improvement. It does not matter if successive improvements are small; what does matter is that every month (or week, or quarter, or whatever period is appropriate) some kind of improvement has actually taken place.

The structure of improvement ideas

There have been hundreds of ideas relating to operations improvement that have been proposed over the last few decades. To understand how these ideas relate to each other it is important to distinguish between:

- The broad approaches to improvement – some improvement approaches have been used for over a century (for example, some work study approaches, see Chapter 9), while others are relatively recent (for example, Six Sigma, explained later).
- The elements contained within improvement approaches – do not think that approaches to improvement are different in all respects. There are many elements that are common to several approaches.
- The improvement techniques – there are many 'step-by-step' techniques and tools that can be used to find improved ways of doing things; some of these use quantitative modelling and others are more qualitative.

SHORT CASE The Checklist Manifesto[4]

Improvement methodologies are often associated with repetitive operations. Performing the same task repeatedly means that there are plenty of opportunities to 'get it right'. The whole idea behind continuous improvement derives from this simple idea. By contrast operations that have to perform more difficult activities, especially those that call for expert judgement and diagnostic ability, must call for equally complex improvement approaches, right? Well, no, according to Atul Gawande, a physician at the prestigious Johns Hopkins Hospital. Mr Gawande thinks that the very opposite is true. Although medicine is advancing at an astounding rate and medical journals produce learned papers adding the results of advanced research to an ever-expanding pool of knowledge, the medical profession overall does not always have a reliable method for learning from its mistakes. Atul Gawande's idea is that his, and similar 'knowledge-based' professions, are in danger of sinking under the weight of facts. Scientists are accumulating more and more information and professions are fragmenting into ever narrower specialisms.

Mr Gawande tells the story of Peter Pronovost, a specialist in critical care at Johns Hopkins Hospital, who in 2001 tried to reduce the number of patients who were becoming infected on account of the use of intravenous central lines. There are five steps that medical teams can take to reduce the chances of contracting such infections. Initially Pronovost simply asked nurses to observe whether doctors took the five steps. What they found was that, at least a third of the time, they missed one or more of the steps. So nurses were authorized to stop doctors who had missed out any of the steps, and, as a matter of course, ask whether existing intravenous central lines should be reviewed. As a result of applying these simple checklist-style rules, the ten-day line-infection rates went down from 11 per cent to zero. In one hospital, it was calculated that, over a year, this simple method had prevented 43 infections, 8 deaths and saved about $2 million. Using the same checklist approach the hospital identified and applied the method to other activities. For example, a check in which nurses asked patients about their pain levels led to untreated pain reducing from 41 per cent to 3 per cent. Similarly, the simple checklists method helped the average length of patient stay in intensive care to fall by half. When Pronovost's approach was adopted by other hospitals, within 18 months, 1,500 lives and $175 million had been saved.

Source: Shutterstock.com/Robyn Mackenzie

Mr Gawande describes checklists used in this way as a 'cognitive net' – a mechanism that can help prevent experienced people from making errors due to flawed memory and attention, and ensure that teams work together. Simple checklists are common in other professions. Civil engineers use them to make certain that complicated structures are assembled on schedule. Chefs use them to make sure that food is prepared exactly to the customers' taste. Airlines use them to make sure that pilots take off safely and also to learn from, now relatively rare, crashes. Indeed, Mr Gawande is happy to acknowledge that checklists are not a new idea. He tells the story of the prototype of the Boeing B17 Flying Fortress that crashed after take-off on its trial flight in 1935. Most experts said that the bomber was 'too complex to fly'. Facing bankruptcy, Boeing investigated and discovered that, confronted with four engines rather than two, the pilot forgot to release a vital locking mechanism. But Boeing created a pilot's checklist, in which the fundamental actions for the stages of flying were made a mandated part of the pilot's job. In the following years, B17s flew almost 2 million miles without a single accident. Even for pilots, many of whom are rugged individualists, says Mr Gawande, it is usually the application of routine procedures that saves planes when things go wrong, rather than 'hero-pilotry' so fêted by the media. It is discipline rather than brilliance that preserves life. In fact, it is discipline that leaves room for brilliance to flourish.

The best way to understand improvement is to deal with the elements contained within improvement approaches first, see how they come together to form broad approaches to improvement, and then examine some typical improvement techniques.

The section following that (see pages 588–598) will then show how these elements are combined to form different improvement approaches.

THE KEY ELEMENTS OF OPERATIONS IMPROVEMENT

✻ Operations principle

The various approaches to improvement draw from a common group of elements.

The elements of improvement are the individual basic fundamental ideas of improvement. Think of these elements of improvement as the building blocks of the various improvement approaches that we shall look at later. Here we explain some, but not all (there are lots), of the more common elements in use today.

Improvement cycles

An important element within some improvement approaches is the use of a literally never-ending process of repeatedly questioning and re-questioning the detailed working of a process or activity. This repeated and cyclical questioning is usually summarized by the idea of the improvement cycle, of which there are many, but two are widely used models – the PDCA cycle (sometimes called the Deming Cycle, named after the famous quality 'guru', W.E. Deming) and the DMAIC (pronounced De-Make) cycle, made popular by the Six Sigma approach (see later). The PDCA cycle model is shown in Figure 18.3(a). It starts with the P (for plan) stage, which involves an examination of the current method or the problem area being studied. This involves collecting and analysing data so as to formulate a plan of action which is intended to improve performance. Once a plan for improvement has been agreed, the next step is the D (for do) stage. This is the implementation stage during which the plan is tried out in the operation. This stage may itself involve a mini-PDCA cycle as the problems of implementation are resolved. Next comes the C (for check) stage where the new implemented solution is evaluated to see whether it has resulted in the expected performance improvement. Finally, at least for this cycle, comes the A (for act) stage. During this stage the change is consolidated or standardized if it has been successful. Alternatively, if the change has not been successful, the lessons learned from the 'trial' are formalized before the cycle starts again.

The DMAIC cycle is in some ways more intuitively obvious than the PDCA cycle insomuch as it follows a more 'experimental' approach. The DMAIC cycle starts with (D), defining the problem or problems, partly to understand the scope of what needs to be done and partly to define exactly the requirements of the process improvement. Often at this stage a formal goal or target for the improvement is set. After definition comes (M), the measurement stage. This stage involves validating the problem to make sure that it really is a problem worth solving, using data to refine the problem and measuring exactly what is happening. Once these measurements have been established, they can be (A), analysed. The analysis stage is sometimes seen as an opportunity to develop hypotheses as to what the root causes of the problem really are. Such hypotheses are

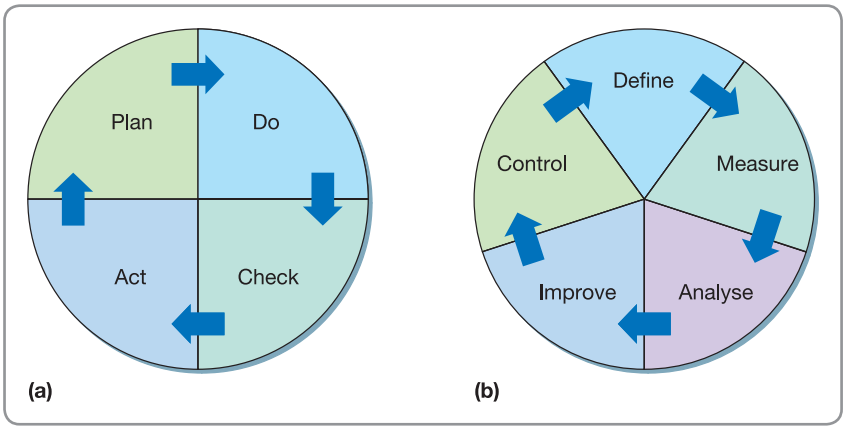

Figure 18.3 (a) The plan–do–check–act, or 'Deming' improvement cycle, and (b) the define–measure–analyse–improve–control, or DMAIC Six-Sigma improvement cycle

validated (or not) by the analysis and the main root causes of the problem identified. Once the causes of the problem are identified, work can begin on (I), improving the process. Ideas are developed to remove the root causes of problems, solutions are tested and those solutions that seem to work are implemented, formalized and results measured. The improved process needs then to be continually monitored and (C), controlled, to check that the improved level of performance is sustained. After this point the cycle starts again and defines the problems which are preventing further improvement. Remember though, it is the last point about both cycles that is the most important – the cycle starts again. It is only by accepting that in a continuous improvement philosophy these cycles quite literally never stop that improvement becomes part of every person's job.

A process perspective

Even if some improvement approaches do not explicitly or formally include the idea that taking a process perspective should be central to operations improvement, almost all do so implicitly. This has two major advantages. First, it means that improvement can be focused on what actually happens rather than which part of the organization has responsibility for what happens. In other words, if improvement is not reflected in the process of creating products and services, then it is not really improvement as such. Second, as we have mentioned before, all parts of the business manage processes. This is what we call operations as activity rather than operations as a function. So, if improvement is described in terms of how processes can be made more effective, those messages will have relevance for all the other functions of the business in addition to the operations function.

End-to-end processes

Some improvement approaches take the process perspective further and prescribe exactly how processes should be organized. One of the more radical prescriptions of Business Process Re-engineering (BPR, see later), for example, is the idea that operations should be organized around the total process which adds value for customers, rather than the functions or activities which perform the various stages of the value-adding activity. We have already pointed out the difference between conventional processes within a specialist function, and an end-to-end business process (in Chapter 1). Identified customer needs are entirely fulfilled by an 'end-to-end' business process. In fact the processes are designed specifically to do this, which is why they will often cut across conventional organizational boundaries. Figure 18.4 illustrates this idea.

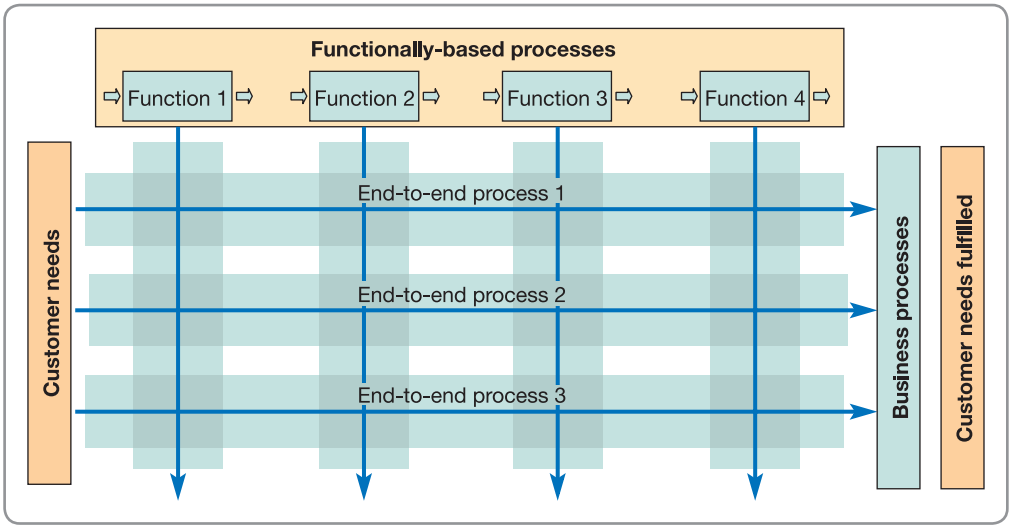

Figure 18.4 BPR advocates reorganizing (re-engineering) micro operations to reflect the natural customer-focused business processes

Evidence-based problem-solving

In recent years there has been a resurgence of the use of quantitative techniques in improvement approaches. Six Sigma (see later) in particular promotes systematic use of (preferably quantitative) evidence. Yet Six Sigma is not the first of the improvement approaches to use quantitative methods (some of the TQM gurus promoted statistical process control, for example), although it has done a lot to emphasize the use of quantitative evidence. In fact much of the considerable training required by Six Sigma consultants is devoted to mastering quantitative analytical techniques. However, the statistical methods used in improvement activities do not always reflect conventional academic statistical knowledge as such. They emphasize observational methods of collecting data and the use of experimentation to examine hypotheses. Techniques include graphical methods, analysis of variance, and two-level factorial experiment design. Underlying the use of these techniques is an emphasis on the scientific method, responding only to hard evidence, and using statistical software to facilitate analysis.

Customer centricity

There is little point in improvement unless it meets the requirements of the customers. However, in most improvement approaches, meeting the expectations of customers means more than this. It involves the whole organization in understanding the central importance of customers to its success and even to its survival. Customers are seen, not as being external to the organization, but as the most important part of it. However, the idea of being customer-centric does not mean that customers must be provided with everything that they want. Although 'What's good for customers' may frequently be the same as 'What's good for the business', it is not always. Operations managers are always having to strike a balance between what customers would like and what the operation can afford (or wants) to do.

Voice of the customer (VOC)

The 'voice of the customer' (VOC) is an idea that is closely related to the idea of customer centricity. The term means capturing a customer's requirements, expectations, perceptions and preferences in some depth. Sometimes a VOC exercise is done as part of new service and product development as part of Quality Function Deployment (QFD) (explained in Chapter 5). Sometimes it is part of a more general improvement activity. There are several ways to do this, but it usually involves using market research to derive a comprehensive set of customer requirements, which is ordered into a hierarchical structure, often prioritized to indicate the relative importance of different aspects of operations performance.

Systems and procedures

Improvement is not something that happens simply by getting everyone to 'think improvement'. Some type of system that supports the improvement effort may be needed. An improvement system (sometimes called a 'quality system') is defined as: *'the organizational structure, responsibilities, procedures, processes and resources for implementing quality management.*[5] It should . . . *define and cover all facets of an organization's operation, from identifying and meeting the needs and requirements of customers, design, planning, purchasing, manufacturing, packaging, storage, delivery and service, together with all relevant activities carried out within these functions. It deals with organization, responsibilities, procedures and processes. Put simply* [it] *is good management practice.*[6]

Reduce process variation

Processes change over time, as does their performance. Some aspect of process performance (usually an important one) is measured periodically (either as a single measurement or as a small sample of measurements). These are then plotted on a simple timescale. This has a

number of advantages. The first is to check that the performance of the process is, in itself, acceptable (capable). They can also be used to check if process performance is changing over time, and to check on the extent of the variation in process performance. Earlier (in Chapter 17) we illustrated how random variation in the performance of any process could obscure what was really happening within the process. So a potentially useful method of identifying improvement opportunities is to try and identify the sources of random variation in process performance. Statistical process control is one way of doing this.

Synchronized flow

This is another idea that we have seen before (in Chapter 15, as part of the lean philosophy). Synchronized flow means that items in a process, operation or supply network flow smoothly and with even velocity from start to finish. This is a function of how inventory accumulates within the operation. Whether inventory is accumulated in order to smooth differences between demand and supply, or as a contingency against unexpected delays, or simply to batch for purposes of processing or movement, it all means that flow becomes asynchronous. It waits as inventory rather than progressing smoothly on. Once a state of perfect synchronization of flow has been achieved, it becomes easier to expose any irregularities of flow which may be the symptoms of more deep-rooted underlying problems.

Emphasize education/training

Several improvement approaches stress the idea that structured training and organization of improvement should be central to improvement. Not only should the techniques of improvement be fully understood by everyone engaged in the improvement process, the business and organizational context of improvement should also be understood. After all, how can one improve without knowing what kind of improvement would best benefit the organization and its customers? Furthermore, education and training has an important part to play in motivating all staff towards seeing improvement as a worthwhile activity. Some improvement approaches in particular place great emphasis on formal education. Six Sigma, for example (see later), and its proponents often mandate a minimum level of training (measured in hours) that they deem necessary before improvement projects should be undertaken.

Perfection is the goal

Almost all organization-wide improvement programmes will have some kind of goal or target that the improvement effort should achieve. And while targets can be set in many different ways, some improvement authorities hold that measuring process performance against some kind of absolute target does most for encouraging improvement. An 'absolute target' literally means the theoretical level of perfection – for example, zero errors, instant delivery, delivery absolutely when promised, infinite flexibility, zero waste, etc. Of course, in reality such perfection may never be achievable. That is not the point. What is important is that current performance can be calibrated against this target of perfection in order to indicate how much more improvement is possible. Improving (for example) delivery accuracy by 5 per cent may seem good until it is realized that only an improvement of 30 per cent would eliminate all late deliveries.

Waste identification

All improvement approaches aspire to eliminate waste. In fact, any improvement implies that some waste has been eliminated, where waste is any activity that does not add value. But the identification and elimination of waste is sometimes a central feature. For example (as we discussed in Chapter 15) it is arguably the most significant part of the lean philosophy.

Include everybody

Harnessing the skills and enthusiasm of every person and all parts of the organization seems an obvious principle of improvement. The phrase 'quality at source' is sometimes used, stressing the impact that each individual has on improvement. The contribution of all individuals in the organization may go beyond understanding their contribution to 'not make mistakes'. Individuals are expected to bring something positive to improving the way they perform their jobs. The principles of 'empowerment' are frequently cited as supporting this aspect of improvement. When Japanese improvement practices first began to migrate in the late 1970s, this idea seemed even more radical. Yet now it is generally accepted that individual creativity and effort from all staff represents a valuable source of development. However, not all improvement approaches have adopted this idea. Some authorities believe that a small number of internal improvement consultants or specialists offer a better method of organizing improvement. However, these two ideas are not incompatible. Even with improvement specialists used to lead improvement efforts, the staff who actually operate the process can still be used as a valuable source of information and improvement ideas.

Develop internal customer–supplier relationships

One of the best ways to ensure that external customers are satisfied is to establish the idea that every part of the organization contributes to external customer satisfaction by satisfying its own internal customers. This idea was introduced in earlier, as was the related concept of service level agreements (SLAs) (Chapter 17). It means stressing that each process in an operation has a responsibility to manage these internal customer–supplier relationships. They do this primarily by defining as clearly as possible what their own and their customers' *requirements* are. In effect this means defining what constitutes 'error-free' service – the quality, speed, dependability and flexibility required by internal customers.

THE BROAD APPROACHES TO MANAGING IMPROVEMENT

Many of the elements described above are present in one or more of the commonly used approaches to improvement. Some of these approaches have already been described. For example, both lean (Chapter 15) and TQM (Chapter 17) have been discussed in some detail. In this section we will briefly re-examine TQM and lean, specifically from an improvement perspective, and also add two further approaches – Business Process Re-engineering (BPR) and Six Sigma.

✻ Operations principle

There is no one universal approach to improvement.

Total quality management as an improvement approach

Total quality management was one of the earliest management 'fashions'. Its peak of popularity was in the late 80s and early 90s. As such it has suffered from something of a backlash in recent years. Yet the general precepts and principles that constitute TQM are still hugely influential. Few, if any, managers have not heard of TQM and its impact on improvement. Indeed, TQM has come to be seen as an approach to the way operations and processes should be managed and improved, generally. Even if TQM is not the label given to an improvement initiative, many of its elements will almost certainly have become routine. It is best thought of as a philosophy of how to approach improvement. This philosophy, above everything, stresses the 'total' of TQM. It is an approach that puts quality (and indeed improvement generally) at the heart of everything that is done by an operation. As a reminder, this totality can be summarized by the way TQM lays particular stress on the following elements (see Chapter 17):

- meeting the needs and expectations of customers;
- improvement covers all parts of the organization (and should be group-based);

SHORT CASE Improvement at Heineken[7]

Heineken International produces and sells beer around the world with growing sales, especially in its Heineken and Amstel brands. However, sales growth can put pressure on any company's operations. For example, Heineken's Zoeterwoude facility, a packaging plant that fills bottles and cans in the Netherlands, has had to increase its volume by between 8 and 10 per cent per year on a regular basis. In a competitive market, the company faced two challenges. First, it needed to improve its operations processes to reduce its costs. Second, because it would have taken a year to build a new packaging line, it needed to improve the efficiency of its existing lines in order to increase its capacity. So, improving line efficiency was vital if the plant was to cut its costs and create the extra capacity it needed to delay investment in a new packaging line.

The objective of the improvement project was to improve the plant's operational equipment efficiency (OEE) (see Chapter 11 for a discussion of OEE) by 20 per cent. Setting a target of 20 per cent was seen as important because it was challenging yet achievable, as well as meeting the cost and capacity objectives of the project. It was also decided to focus the improvement project around two themes: (a) obtaining accurate operational data that could be converted into useful business information on which improvement decisions could be based; and (b) changing the culture of the operation to promote fast and effective decision making. This would help people at all levels in the plant to have access to accurate and up-to-date information as well as encouraging staff to focus on the improvement of how they do their job rather than just 'doing the job'. Before the improvement, project staff at the Zoeterwoude plant had approached problem-solving as an ad hoc activity, only to be done when circumstances made it unavoidable. By contrast, the improvement initiative taught the staff on each packaging line to use various problem-solving techniques such as cause-effect and Pareto diagrams (discussed later in this chapter). Other techniques included the analysis of improved equipment maintenance and failure mode and effective analysis (FMEA). (Both are discussed in Chapter 19.)

'Until we started using these techniques', says Wilbert Raaijmakers, Heineken Netherlands Brewery Director, *'there was little consent regarding what was causing any problems. There was poor communication between the various departments and job grades. For example, maintenance staff believed that production stops were caused by operating errors, while operators were of the opinion that poor maintenance was the cause.'* The use of better information, analysis and improvement techniques helped the staff to identify and treat the root causes of problems. With many potential improvements to make, staff teams were encouraged to set priorities that would reflect the overall improvement target. There was also widespread use of benchmarking performance against targets periodically so that progress could be reviewed.

Source: Shutterstock.com/Valentyn Volkov

At the end of 12 months the improvement project had achieved its objectives of a 20 per cent improvement in OEE, not just for one packaging line but for all nine. This allowed the plant to increase the volume of its exports and cut its costs significantly. Not only that, but other aspects of the plant's performance improved. Up to that point, the plant had gained a reputation for poor delivery dependability. After the project it was seen by the other operations in its supply chain as a much more reliable partner. Yet Wilbert Raaijmakers still sees room for improvement. *'The optimization of an organization is a never-ending process. If you sit back and do the same thing tomorrow as you did today, you'll never make it. We must remain alert to the latest developments and stress the resulting information to its full potential.'*

- improvement includes every person in the organization (and success is recognized);
- including all costs of quality;
- getting things 'right first time', i.e. designing-in quality rather than inspecting it in;
- developing the systems and procedures which support improvement.

Lean as an improvement approach

The idea of 'lean' spread beyond its Japanese roots and became fashionable in the West at about the same time as TQM. And although its popularity has not declined to the same extent as TQM, over 25 years of experience have diminished the excitement once associated with the approach. But, unlike TQM, it was seen initially as an approach to be used exclusively in manufacturing. Now, lean has become fashionable as an approach that can be applied in service operations. As a reminder (see Chapter 15), the lean approach aims to meet demand instantaneously, with perfect quality and no waste. The key elements of the lean when used as an improvement approach are as follows:

- customer-centricity;
- internal customer–supplier relationships;
- perfection is the goal;
- synchronized flow;
- reduce variation;
- include all people;
- waste elimination.

Some organizations, especially now that lean is being applied more widely in service operations, view waste elimination as the most important of all the elements of the lean approach. In fact, they sometimes see the lean approach as consisting almost exclusively of waste elimination. What they fail to realize is that effective waste elimination is best achieved through changes in behaviour. It is the behavioural change brought about through synchronized flow and customer triggering that provides the window onto exposing and eliminating waste.

Business process re-engineering (BPR)

The idea of business process re-engineering originated in the early 1990s when Michael Hammer proposed that, rather than using technology to automate work, it would be better applied to doing away with the need for the work in the first place ('don't automate, obliterate'). In doing this he was warning against establishing non-value-added work within an information technology system where it would be even more difficult to identify and eliminate. All work, he said, should be examined for whether it adds value for the customer and if not processes should be redesigned to eliminate it. In doing this BPR was echoing similar objectives in both scientific management and, more recently, lean approaches. But BPR, unlike those two earlier approaches, advocated radical changes rather than incremental changes to processes. Shortly after Hammer's article, other authors developed the ideas, again the majority of them stressing the importance of a radical approach to elimination of non-value-added work.

BPR has been defined as:[8] '*the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed*'. But there is far more to it than that. In fact, BPR was a blend of a number of ideas which had been current in operations management for some time. Lean concepts, process flow charting, critical examination in method study, operations network management and customer-focused operations all contribute to the BPR concept. It was the potential of information technologies to enable the fundamental redesign of processes, however, which acted as the catalyst in bringing these ideas together. It was the information technology that allowed radical process redesign, even if many of the methods used to achieve the redesign had been explored before. The main principles of BPR can be summarized in the following points:

- Rethink business processes in a cross-functional manner which organizes work around the natural flow of information (or materials or customers).
- Strive for dramatic improvements in performance by radically rethinking and redesigning the process.
- Have those who use the output from a process perform the process. Check to see if all internal customers can be their own supplier rather than depending on another function

in the business to supply them (which takes longer and separates out the stages in the process).

- Put decision points where the work is performed. Do not separate those who do the work from those who control and manage the work.

Example[9]

We can illustrate this idea of reorganizing (or re-engineering) around business processes through the following simple example. Figure 18.5(a) shows the traditional organization of a trading company which purchases consumer goods from several suppliers, stores them, and

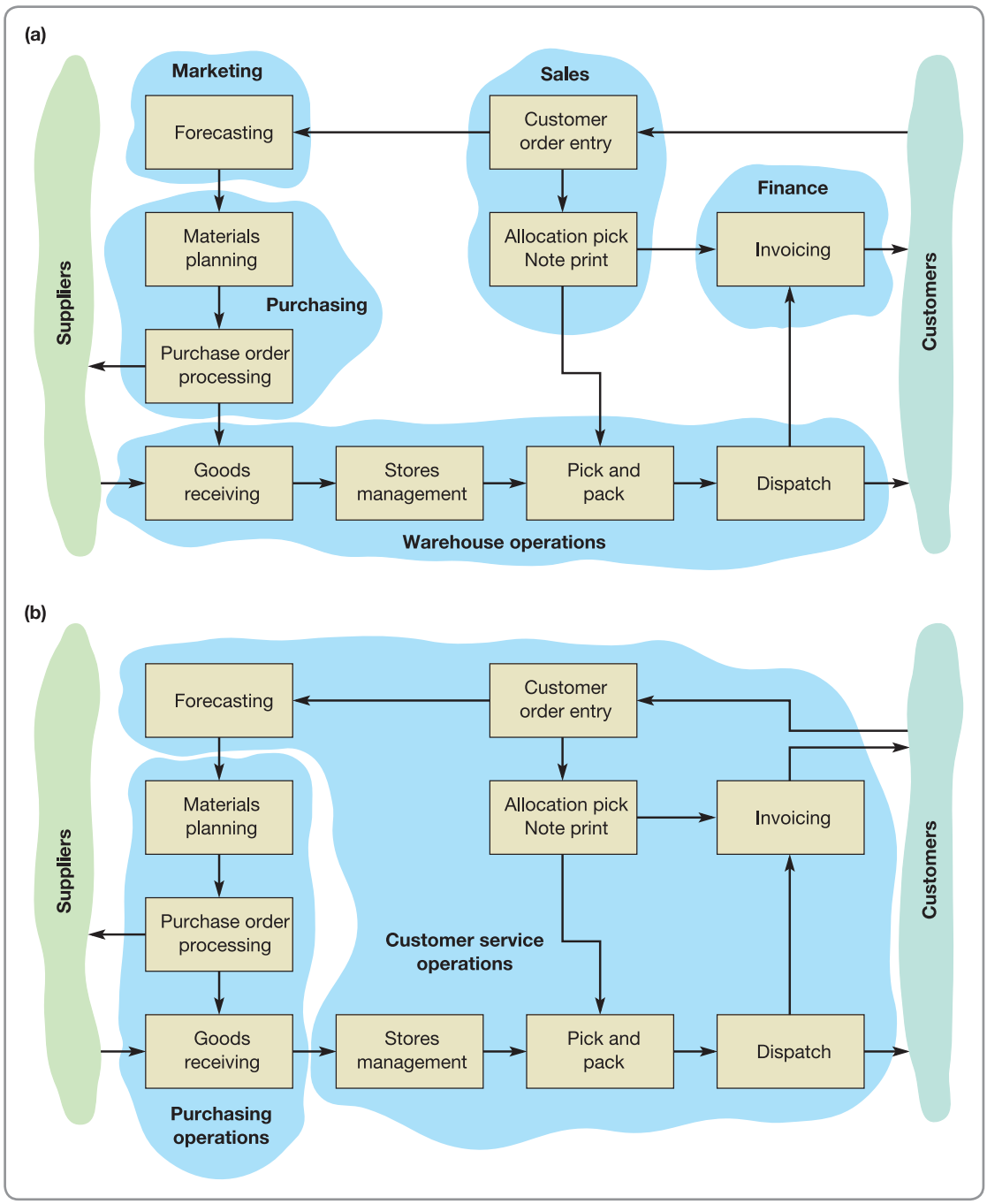

Figure 18.5 (a) Before and (b) after re-engineering a consumer goods trading company

sells them on to retail outlets. At the heart of the operation is the warehouse which receives the goods, stores them, and packs and dispatches them when they are required by customers. Orders for more stock are placed by Purchasing which also takes charge of materials planning and stock control. Purchasing buys the goods based on a forecast which is prepared by Marketing, which takes advice from the Sales department which is processing customers' orders. When a customer does place an order, it is the Sales department's job to instruct the warehouse to pack and dispatch the order and tell the Finance department to invoice the customer for the goods. So, traditionally, five departments (each a micro-operation) have between them organized the flow of materials and information within the total operation. But at each interface between the departments there is the possibility of errors and miscommunication arising. Furthermore, *who is responsible for looking after the customer's needs?* Currently, three separate departments all have dealings with the customer. Similarly, *who is responsible for liaising with suppliers?* This time two departments have contact with suppliers.

Eventually the company reorganized around two essential business processes. The first process (called purchasing operations) dealt with everything concerning relationships with suppliers. It was this process's focused and unambiguous responsibility to develop good working relationships with suppliers. The other business process (called customer service operations) had total responsibility for satisfying customers' needs. This included speaking 'with one voice' to the customer.

Critical commentary

BPR has aroused considerable controversy, mainly because BPR sometimes looks only at work activities rather than at the people who perform the work. Because of this, people become 'cogs in a machine'. Many of these critics equate BPR with the much earlier principles of scientific management, pejoratively known as 'Taylorism'. Generally these critics mean that BPR is overly harsh in the way it views human resources. Certainly there is evidence that BPR is often accompanied by a significant reduction in staff. Studies at the time when BPR was at its peak often revealed that the majority of BPR projects could reduce staff levels by over 20 per cent. Often BPR was viewed as merely an excuse for getting rid of staff. Companies that wished to 'downsize' were using BPR as the pretext, putting the short-term interests of the shareholders of the company above either their longer-term interests or the interests of the company's employees. Moreover, a combination of radical redesign together with downsizing could mean that the essential core of experience was lost from the operation. This left it vulnerable to any marked turbulence since it no longer possessed the knowledge and experience of how to cope with unexpected changes.

Six Sigma

The Six Sigma approach was first popularized by Motorola, the electronics and communications systems company. When it set its quality objective as 'total customer satisfaction' in the 1980s, it started to explore what the slogan would mean to its operations processes. They decided that true customer satisfaction would only be achieved when its products were delivered when promised, with no defects, with no early-life failures, and when the product did not fail excessively in service. To achieve this, Motorola initially focused on removing manufacturing defects. However, it soon came to realize that many problems were caused by latent defects, hidden within the design of its products. These may not show initially but eventually could cause failure in the field. The only way to eliminate these defects was to make sure that design specifications were tight (i.e. narrow tolerances) and its processes very capable.

Motorola's Six Sigma quality concept was so named because it required the natural variation of processes (± 3 standard deviations) to be half their specification range. In other words, the specification range of any part of a product or service should be ± 6 the standard deviation of the process (see Chapter 17). The Greek letter sigma (σ) is often used to indicate the standard deviation of a process, hence the Six Sigma label. Figure 18.6 illustrates the effect of progressively narrowing process variation on the number of defects produced by the process, in terms of defects per million. The defects per million measure is used within the Six Sigma approach to emphasize the drive towards a virtually zero defect objective.[10] Now the definition of Six Sigma has widened to well beyond this rather narrow statistical perspective. General Electric (GE), who were probably the best known of the early adopters of Six Sigma, defined it as '*A disciplined methodology of defining, measuring, analysing, improving, and controlling the quality in every one of the company's products, processes, and transactions – with the ultimate goal of virtually eliminating all defects.*' So, now Six Sigma should be seen as a broad improvement concept rather than a simple examination of process variation, even though this is still an important part of process control, learning and improvement.

Measuring performance

The Six Sigma approach uses a number of related measures to assess the performance of operations processes.

- **A defect** is a failure to meet customer required performance (defining performance measures from a customer's perspective is an important part of the Six Sigma approach).
- **A defect unit or item** is any unit of output that contains a defect (i.e. only units of output with no defects are not defective; defective units will have one or more than one defects).
- **A defect opportunity** is the number of different ways a unit of output can fail to meet customer requirements (simple products or services will have few defect opportunities, but very complex products or services may have hundreds of different ways of being defective).
- **Proportion defective** is the percentage or fraction of units that have one or more defect.
- **Process yield** is the percentage or fraction of total units produced by a process that are defect free (i.e. 1 − proportion defective).
- **Defect per unit (DPU)** is the average number of defects on a unit of output (the number of defects divided by the number of items produced).
- **Defects per opportunity** is the proportion or percentage of defects divided by the total number of defect opportunities (the number of defects divided by (the number items produced × the number of opportunities per item)).
- **Defects per million opportunities (DPMO)** is exactly what it says, the number of defects which the process will produce if there were one million opportunities to do so.
- **The Sigma measurement**[11] is derived from the DPMO and is the number of standard deviations of the process variability that will fit within the customer specification limits.

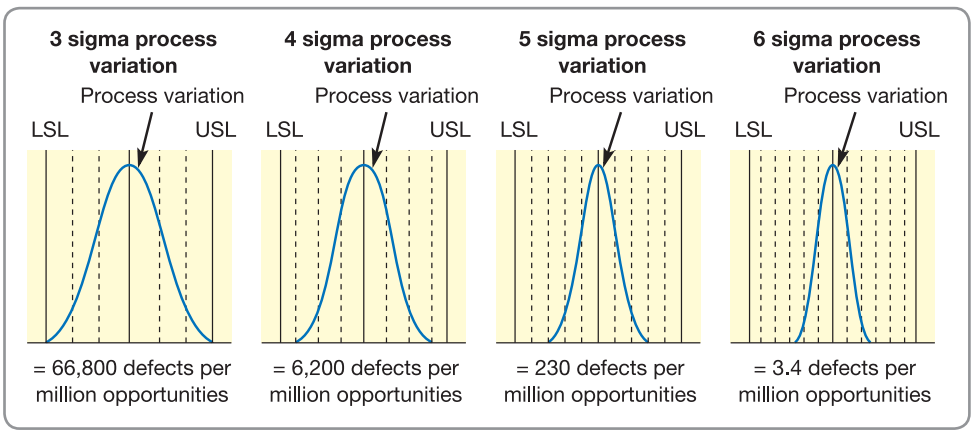

Figure 18.6 Process variation and its impact on process defects per million

Worked example

An insurance process checks details of insurance claims and arranges for customers to be paid. It samples 300 claims at random at the end of the process. They find that 51 claims had one or more defects and there were 74 defects in total. Four types of error were observed, coding errors, policy conditions errors, liability errors and notification errors.

$$\text{Proportion defective} = \frac{\text{Number of defects}}{\text{Number of units processed}}$$

$$= \frac{51}{300} = 0.17 \text{ (17\% defective)}$$

$$\text{Yield} = 1 - \text{proportion of defectives}$$

$$= 1 - 0.17 = 0.83 \text{ or (83\% yield)}$$

$$\text{Defects per unit} = \frac{\text{Number of defects}}{\text{Numer of units processed}}$$

$$= \frac{74}{300} = 0.247 \text{ (or 24.7) DPU}$$

$$\text{Defects per opportunity} = \frac{\text{Number of defects}}{\text{Number of units produced} \times \text{Number of opportunities}}$$

$$= \frac{74}{300 \times 4} = 0.062 \text{ DPO}$$

$$\text{Defects per million opportunities} = \text{DPO} \times 10^6$$

$$= 62{,}000 \text{ DPMO}$$

Although the scope of Six Sigma is disputed, elements frequently associated with Six Sigma include the following:

- **Customer-driven objectives.** Six Sigma is sometimes defined as 'the process of comparing process outputs against customer requirements'. It uses a number of measures to assess the performance of operations processes. In particular it expresses performance in terms of defects per million opportunities (DPMO).
- **Use of evidence.** Although Six Sigma is not the first of the new approaches to operations to use statistical methods it has done a lot to emphasize the use of quantitative evidence.
- **Structured improvement cycle.** The structured improvement cycle used in Six Sigma is the DMAIC cycle.
- **Process capability and control.** Not surprisingly, given its origins, process capability and control is important within the Six Sigma approach.
- **Process design.** Latterly Six Sigma proponents also include process design into the collection of elements that define the Six Sigma approach.
- **Structured training and organization of improvement.** The Six Sigma approach holds that improvement initiatives can only be successful if significant resources and training are devoted to their management.

The 'martial arts' analogy

The terms that have become associated with Six Sigma experts (and denote their level of expertise) are, Master Black Belt, Black Belt and Green Belt. Master Black Belts are experts in the use of Six Sigma tools and techniques as well as how such techniques can be used

and implemented. Primarily Master Black Belts are seen as teachers who can not only guide improvement projects, but also coach and mentor Black Belts and Green Belts who are closer to the day-to-day improvement activity. They are expected to have the quantitative analytical skills to help with Six Sigma techniques and also the organizational and interpersonal skills to teach and mentor. Given their responsibilities, it is expected that Master Black Belts are employed full-time on their improvement activities. Black Belts can take a direct hand in organizing improvement teams. Like Master Black Belts, Black Belts are expected to develop their quantitative analytical skills and also act as coaches for Green Belts. Black Belts are dedicated full-time to improvement, and although opinions vary on how many Black Belts should be employed in an operation, some organizations recommend one Black Belt for every hundred employees. Green Belts work within improvement teams, possibly as team leaders. They have significant amounts of training, although less than Black Belts. Green Belts are not full-time positions; they have normal day-to-day process responsibilities but are expected to spend at least 20 per cent of their time on improvement projects.

SHORT CASE Six Sigma at Xchanging[12]

'I think Six Sigma is powerful because of its definition; it is the process of comparing process outputs against customer requirements. Processes operating at less than 3.4 defects per million opportunities means that you must strive to get closer to perfection and it is the customer that defines the goal. Measuring defects per opportunity means that you can actually compare the process of, say, a human resources process with a billing and collection process.' Paul Ruggier, Head of Process at Xchanging, is a powerful advocate of Six Sigma, and credits the success of the company, at least partly, to the approach.

Xchanging is one of a new breed of companies operating as an outsourcing business for 'back-office' functions for a range of companies, such as Lloyds of London, the insurance centre. Xchanging's business proposition is for the client company to transfer the running of the whole, or part, of their back office to Xchanging, either for a fixed price or one determined by cost savings achieved. The challenge Xchanging face is to run that back office in a more effective and efficient manner than the client company had managed in the past. So, the more effective Xchanging is at running the processes, the greater its profit. To achieve these efficiencies Xchanging offers, on a larger scale, a higher level of process expertise, focus and investment in technology. But above all, they offer a Six Sigma approach. *'Everything we do can be broken down into a process'*, says Paul Ruggier. *'It may be more straightforward in a manufacturing business; frankly they've been using a lot of Six Sigma tools and techniques for decades. But the concept of process improvement is relatively new in many service companies. Yet the concept is powerful. Through the implementation of this approach we have achieved 30 per cent productivity improvements in 6 months.'*

The company also adopts the Six Sigma terminology for its improvement practitioners – Master Black Belts, Black Belts and Green Belts. Attaining the status of Black Belt is very much sought after as well as being fulfilling, says Rebecca Whittaker, who is a Master Black Belt at Xchanging. *'At the end of a project it is about having a process which is redesigned to such an extent, that is simplified and consolidated and people come back and say, "It's so much better than it used to be." It makes their lives better and it makes the business results better and those are the things that make being a Black Belt worthwhile.'*

Source: Shutterstock.com/Kzenon

Rebecca was recruited by Xchanging along with a number of other Master Black Belts as part of a strategic decision to kick-start Six Sigma in the company. It is seen as a particularly responsible position by the company and Master Black Belts are expected to be well versed in the Six Sigma techniques and be able to provide the training and know-how to develop other staff within the company. In Rebecca's case, she has been working as a Six Sigma facilitator for five years, initially as a Green Belt then as a Black Belt.

Typically a person identified as having the right analytical and interpersonal skills will be taken off their job for at least a year, trained and immersed in the concepts of improvement and then sent to work with line staff as project manager/facilitator. Their role as Black Belt will be to guide the line staff to make improvements in the way they do the job. One of the new Black Belts at Xchanging, Sarah Frost, is keen to stress the responsibility she owes to the people who will have to work in the improvement process. '*Being a Black Belt is about being a project manager. It is about working with the staff and combining our skills in facilitation and our knowledge of the Six Sigma process with their knowledge of the business. You always have to remember that you will go on to another project but they* [process staff] *will have to live with the new process. It is about building solutions that they can believe in.*'

Critical commentary

One common criticism of Six Sigma is that it does not offer anything that was not available before. Its emphasis on improvement cycles comes from TQM, its emphasis on reducing variability comes from statistical process control, its use of experimentation and data analysis is simply good quantitative analysis. The only contribution that Six Sigma has made, argue its critics, is using the rather gimmicky martial arts analogy of Black Belt, etc., to indicate a level of expertise in Six Sigma methods. All Six Sigma has done is package pre-existing elements together in order for consultants to be able to sell it to gullible chief executives. In fact it's difficult to deny some of these points. Maybe the real issue is whether it is really a criticism. If bringing these elements together really does form an effective problem-solving approach, why is this a problem?

Six Sigma is also accused of being too hierarchical in the way it structures its various levels of involvement in the improvement activity (as well as the dubious use of martial-arts-derived names such as Black Belt). It is also expensive. Devoting such large amounts of training and time to improvement is a significant investment, especially for small companies. Nevertheless, Six Sigma proponents argue that the improvement activity is generally neglected in most operations and, if it is to be taken seriously, it deserves the significant investment implied by the Six Sigma approach. Furthermore, they argue, if operated well, Six Sigma improvement projects run by experienced practitioners can save far more than their cost. There are also technical criticisms of Six Sigma, most notably that in purely statistical terms the normal distribution which is used extensively in Six Sigma analysis does not actually represent most process behaviour. Other technical criticisms (that are not really the subject of this book) imply that aiming for the very low levels of defects per million opportunities, as recommended by Six Sigma proponents, is far too onerous.

Differences and similarities

In this text we have chosen to very briefly explain four improvement approaches. It could have been more. Enterprise resource planning (ERP, see Chapter 14), total preventive maintenance (TPM, see Chapter 19), lean Sigma (a combination of lean and Six Sigma), and others could have been added. But these four constitute a representative sample of the most commonly used approaches. Nor do we have the space to describe them fully. But there are clearly some common elements between some of these approaches that we have described. Yet there are also differences between them in that each approach includes a different set of elements and therefore a different emphasis and these differences need to be understood. For example, one important

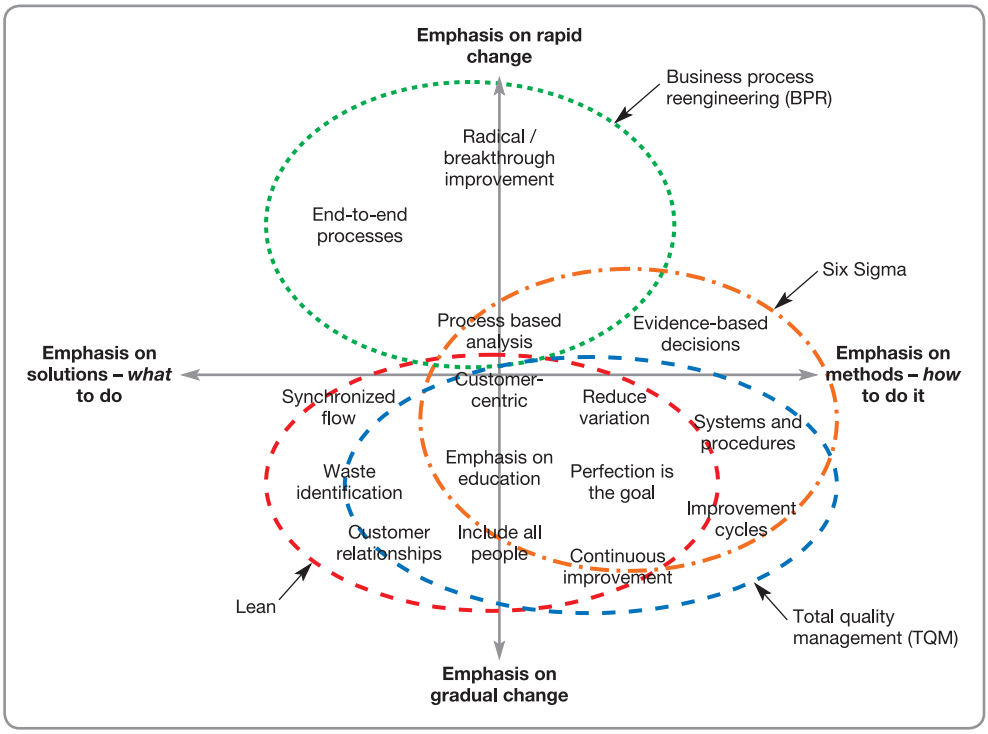

Figure 18.7 The four approaches on the two dimensions of improvement

difference relates to whether the approaches emphasize a gradual, continuous approach to change, or whether they recommend a more radical 'breakthrough' change. Another difference concerns the aim of the approach. What is the balance between whether the approach emphasizes *what* changes should be made or *how* changes should be made? Some approaches have a firm view of what is the best way to organize the operation's processes and resources. Other approaches hold no particular view on what an operation should do but rather concentrate on how the management of an operation should decide what to do. Indeed we can position each of the elements and the approaches that include them. This is illustrated in Figure 18.7. The approaches differ in the extent that they prescribe appropriate operations practice. BPR, for example, is very clear in what it is recommending. Namely, that all processes should be organized on an end-to-end basis. Its focus is *what* should happen rather than *how* it should happen. To a slightly lesser extent lean is the same. It has a definite list of things that processes should or should not be – waste should be eliminated, inventory should be reduced, technology should be flexible, and so on. Contrast this with both Six Sigma and TQM which focus to a far greater extent on *how* operations should be improved. Six Sigma in particular has relatively little to say about what is good or bad in the way operations resources are organized (with the possible exception of emphasizing the negative effects of process variation). Its concern is largely the way improvements should be made: using evidence, using quantitative analysis, using the DMAIC cycle, and so on. They also differ in terms of whether they emphasize gradual or rapid change. BPR is explicit in its radical nature. By contrast TQM and lean both incorporate ideas of continuous improvement. Six Sigma is relatively neutral on this issue and can be used for small or very large changes.

✻ Operations principle

There is significant overlap between the various approaches to improvement in terms of the improvement elements they contain.

Lean Sigma[13]

As if to emphasize the shared elements of the various approaches to operations improvement, some organizations are blending two or more approaches to form hybrids that try and combine their best characteristics. The best known of these is Lean Sigma (also called Lean Six

Sigma or Six Sigma Lean). As its name suggests, Lean Six Sigma is a combination of lean methods and Six Sigma concepts. It attempts to build on the experience, methods and tools that have emerged from the several decades of operational improvement and implementation using lean and Six Sigma approaches separately. Lean Sigma includes the waste reduction, fast throughput time and impact of Lean with the data-driven rigour and variation control of Six Sigma. Some organizations also include other elements from other approaches. For example, the continuous improvement and error-free quality orientation of TQM is frequently included into the concept.

WHAT TECHNIQUES CAN BE USED FOR IMPROVEMENT?

✻ Operations principle

Improvement is facilitated by relatively simple analytical techniques.

All the techniques described in this book and its supplements can be regarded as 'improvement' techniques. However, some techniques are particularly useful for improving operations and processes generally. Here we select some techniques which either have not been described elsewhere or need to be reintroduced in their role of helping operations improvement particularly.

Scatter diagrams

Scatter diagrams provide a quick and simple method of identifying whether there is evidence of a connection between two sets of data: for example, the time at which you set off for work every morning and how long the journey to work takes. Plotting each journey on a graph which has departure time on one axis and journey time on the other could give an indication of whether departure time and journey time are related, and if so, how. Scatter diagrams can be treated in a far more sophisticated manner by quantifying how strong the relationship between the sets of data is. But, however sophisticated the approach, this type of graph only identifies the existence of a relationship, not necessarily the existence of a cause–effect relationship. If the scatter diagram shows a very strong connection between the sets of data, it is important evidence of a cause–effect relationship, but not proof positive. It could be coincidence!

Example: Kaston Pyral Services Ltd (A)

Kaston Pyral Services Ltd (KPS) installs and maintains environmental control, heating and air-conditioning systems. It has set up an improvement team to suggest ways in which it might improve its levels of customer service. The improvement team had completed its first customer satisfaction survey. The survey asked customers to score the service they received from KPS in several ways. For example, it asked customers to score services on a scale of 1 to 10 on promptness, friendliness, level of advice, etc. Scores were then summed to give a 'total satisfaction score' for each customer – the higher the score, the greater the satisfaction. The spread of satisfaction scores puzzled the team and they considered what factors might be causing such differences in the way their customers viewed them. Two factors were put forward to explain the differences:

(a) the number of times in the past year the customer had received a preventive maintenance visit;
(b) the number of times the customer had called for emergency service.

All this data was collected and plotted on scatter diagrams as shown in Figure 18.8. It shows that there seems to be a clear relationship between a customer's satisfaction score and the number of times the customer was visited for regular servicing. The scatter diagram in Figure 18.8(b) is less clear. Although all customers who had very high satisfaction scores had made very few emergency calls, so had some customers with low satisfaction scores. As a result of this analysis, the team decided to survey customers' views on its emergency service.

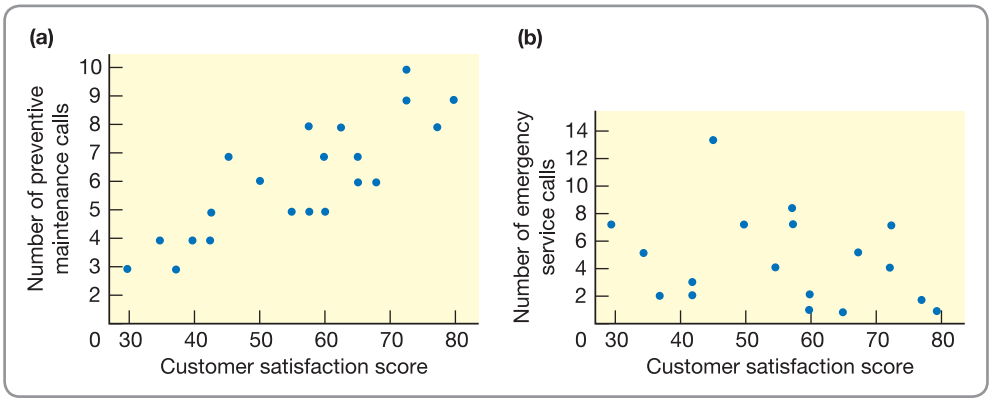

Figure 18.8 **Scatter diagrams for customer satisfaction versus (a) number of preventive maintenance calls and (b) number of emergency service calls**

Process maps (flow charts)

Process maps (sometimes called flow charts in this context) can be used to give a detailed understanding prior to improvement. They were described earlier (in Chapter 4) and are widely used in improvement activities. The act of recording each stage in the process quickly shows up poorly organized flows. Process maps can also clarify improvement opportunities and shed further light on the internal mechanics or workings of an operation. Finally, and probably most importantly, they highlight problem areas where no procedure exists to cope with a particular set of circumstances.

Example: Kaston Pyral Services Ltd (B)

As part of its improvement programme the team at KPS is concerned that customers are not being served well when they phone in with minor queries over the operation of their heating systems. These queries are not usually concerned with serious problems, but often concern minor irritations which can be equally damaging to the customers' perception of KPS's service. Figure 18.9 shows the process map for this type of customer query. The team found the map illuminating. The procedure had never been formally laid out in this way before, and it showed up three areas where information was not being recorded. These are the three points marked with question marks on the process map in Figure 18.9. As a result of this investigation, it was decided to log all customer queries so that analysis could reveal further information on the nature of customer problems.

Cause–effect diagrams

Cause–effect diagrams are a particularly effective method of helping to search for the root causes of problems. They do this by asking what, when, where, how and why questions, but also add some possible 'answers' in an explicit way. They can also be used to identify areas where further data is needed. Cause–effect diagrams (which are also known as 'Ishikawa diagrams') have become extensively used in improvement programmes. This is because they provide a way of structuring group brainstorming sessions. Often the structure involves identifying possible causes under the (rather old-fashioned) headings of: machinery, manpower, materials, methods and money. Yet in practice, any categorization that comprehensively covers all relevant possible causes could be used.

Example: Kaston Pyral Services Ltd (C)

The improvement team at KPS was working on a particular area which was proving a problem. Whenever service engineers were called out to perform emergency servicing for a customer, they took with them the spares and equipment which they thought would be necessary to repair the system. Although engineers could never be sure exactly what materials and equipment

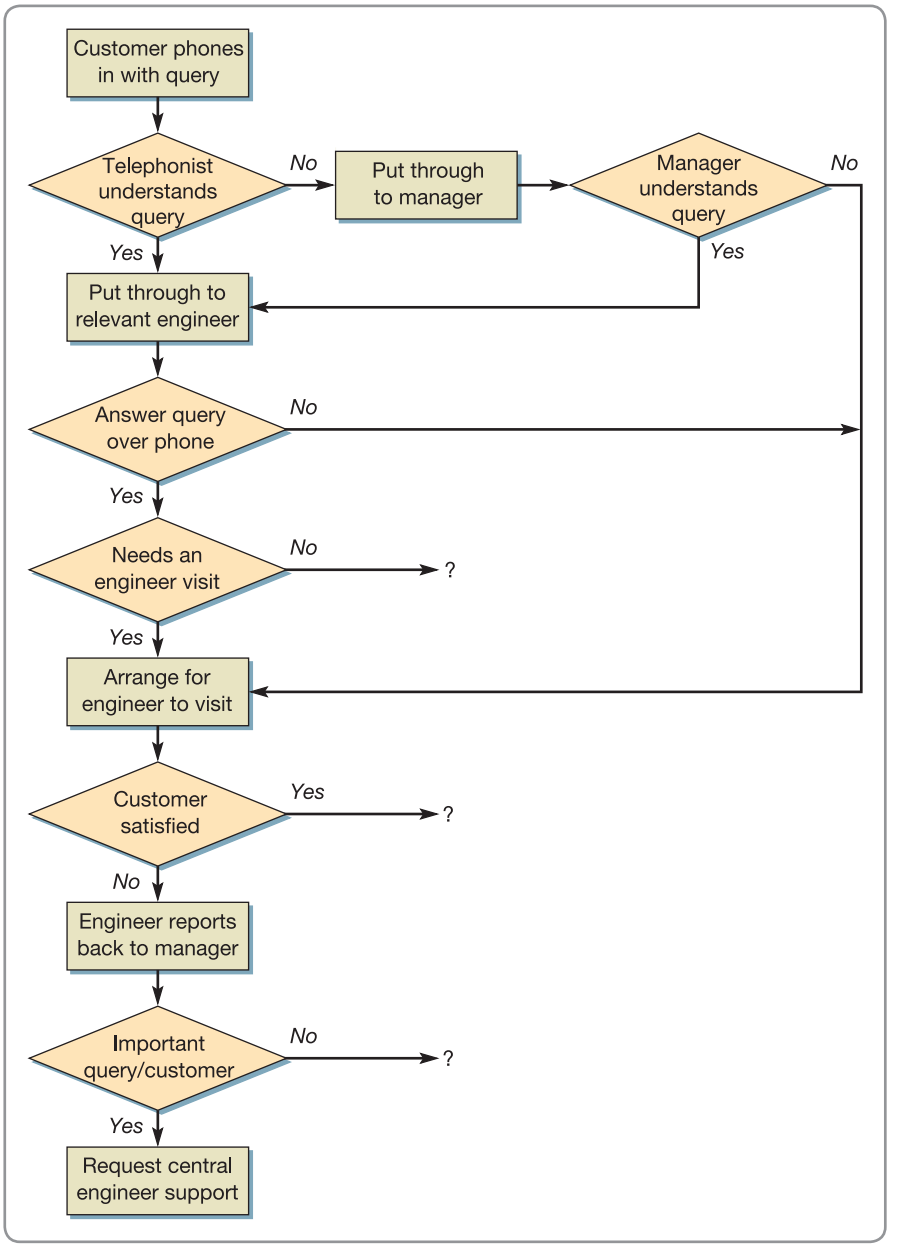

Figure 18.9 **Process map for customer query**

they would need for a job, they could guess what was likely to be needed and take a range of spares and equipment which would cover most eventualities. Too often, however, the engineers would find that they needed a spare that they had not brought with them. The cause–effect diagram for this particular problem, as drawn by the team, is shown in Figure 18.10.

Pareto diagrams

In any improvement process, it is worthwhile distinguishing what is important and what is less so. The purpose of the Pareto diagram (first introduced in Chapter 12) is to distinguish between the 'vital few' issues and the 'trivial many'. It is a relatively straightforward technique which involves arranging items of information on the types of problem or causes of problem into their order of importance (usually measured by frequency of occurrence). This can be used to highlight areas where further decision making will be useful. Pareto analysis is based

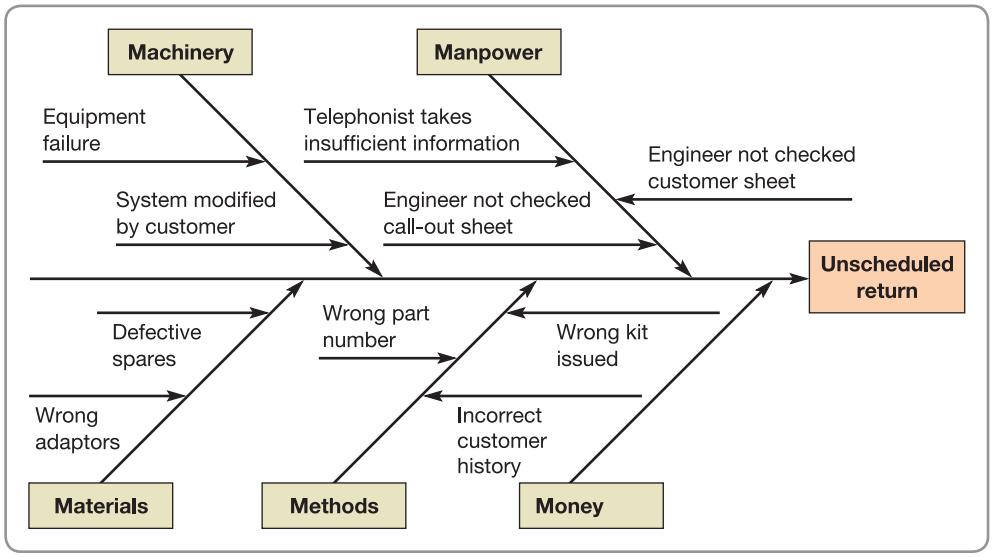

Figure 18.10 Cause–effect diagram of unscheduled returns at KPS

on the phenomenon of relatively few causes explaining the majority of effects. For example, most revenue for any company is likely to come from relatively few of the company's customers. Similarly, relatively few of a doctor's patients will probably occupy most of his or her time.

Example: Kaston Pyral Services Ltd (D)

The KPS improvement team which was investigating unscheduled returns from emergency servicing (the issue described in the cause–effect diagram in Figure 18.11) examined all occasions over the previous 12 months on which an unscheduled return had been made. They categorized the reasons for unscheduled returns as follows:

1 The wrong part had been taken to a job because, although the information which the engineer received was sound, he or she had incorrectly predicted the nature of the fault.

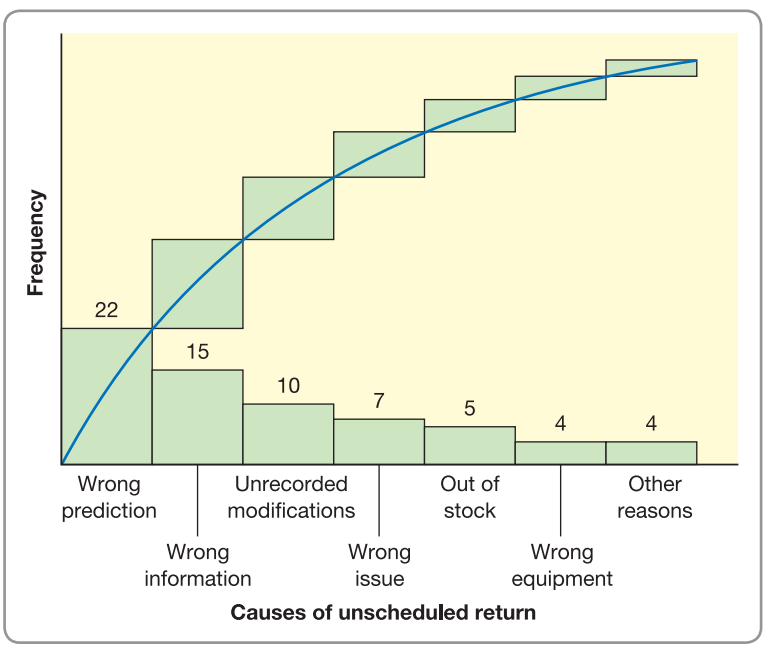

Figure 18.11 Pareto diagram for causes of unscheduled returns

2 The wrong part had been taken to the job because there was insufficient information given when the call was taken.
3 The wrong part had been taken to the job because the system had been modified in some way not recorded on KPS's records.
4 The wrong part had been taken to the job because the part had been incorrectly issued to the engineer by stores.
5 No part had been taken because the relevant part was out of stock.
6 The wrong equipment had been taken for whatever reason.
7 Any other reason.

The relative frequency of occurrence of these causes is shown in Figure 18.11. About a third of all unscheduled returns were due to the first category, and more than half the returns were accounted for by the first and second categories together. It was decided that the problem could best be tackled by concentrating on how to get more information to the engineers which would enable them to predict the causes of failure accurately.

Why–why analysis

Why–why analysis starts by stating the problem and asking *why* that problem has occurred. Once the reasons for the problem occurring have been identified, each of the reasons is taken in turn and again the question is asked *why* those reasons have occurred, and so on. This procedure is continued until either a cause seems sufficiently self-contained to be addressed by itself or no more answers to the question 'Why?' can be generated.

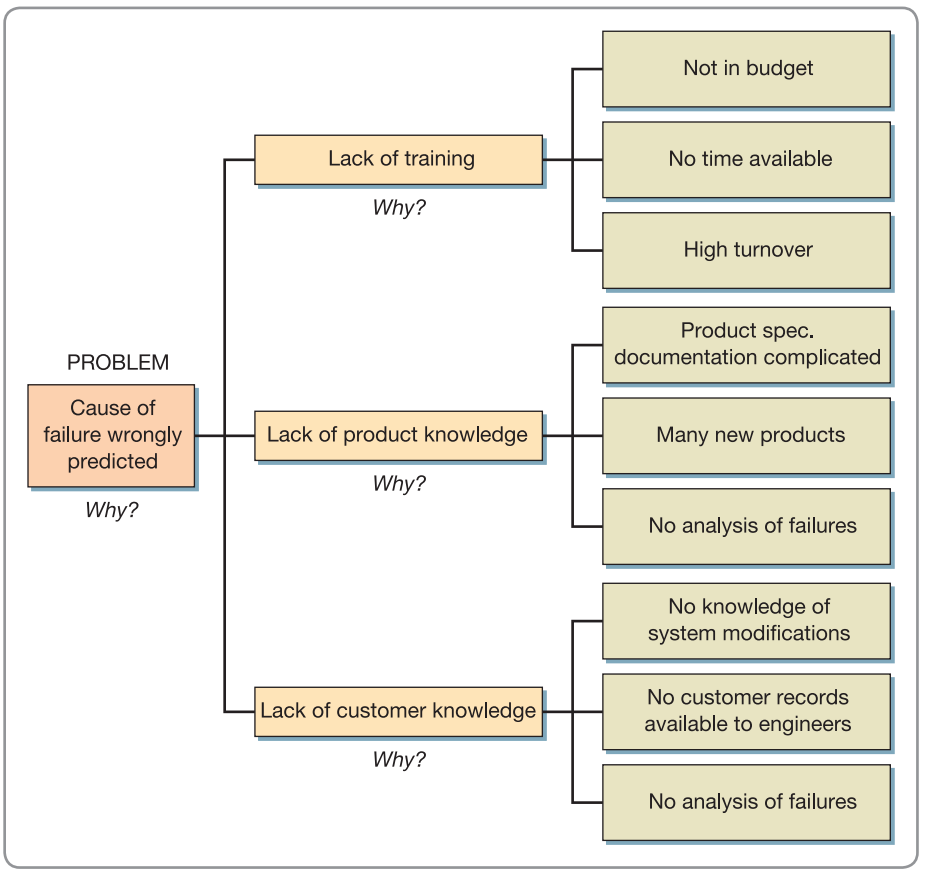

Figure 18.12 Why–why analysis for 'failure wrongly predicted'

Example: Kaston Pyral Services Ltd (E)

The major cause of unscheduled returns at KPS was the incorrect prediction of reasons for the customer's system failure. This is stated as the 'problem' in the why–why analysis in Figure 18.12. The question is then asked, why was the failure wrongly predicted? Three answers are proposed: first, that the engineers were not trained correctly; second, that they had insufficient knowledge of the particular product installed in the customer's location; and third, that they had insufficient knowledge of the customer's particular system with its modifications. Each of these three reasons is taken in turn, and the questions are asked, why is there a lack of training, why is there a lack of product knowledge, and why is there a lack of customer knowledge? And so on.

SUMMARY ANSWERS TO KEY QUESTIONS

Check and improve your understanding of this chapter using self-assessment questions and a personalized study plan, a video case study, and an eText – all at **www.myomlab.com**.

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› Why is improvement so important in operations management?

- Improvement is now seen as the prime responsibility of operations management. Of the four areas of operations management activity (direct, design, deliver and develop) the focus of most operations managers has shifted towards 'develop', that is, improvement. Furthermore all operations management activities are really concerned with improvement in the long term. And all four activities are really interrelated and interdependent. Also, companies in many industries are having to improve simply to retain their position relative to their competitors. This is sometimes called the 'Red Queen' effect.
- A common distinction is between radical or breakthrough improvement on one hand, and continuous or incremental improvement on the other.

› What are the key elements of operations improvement?

- There are many 'elements' that are the building blocks of improvement approaches. The ones described in this chapter are:
  - improvement cycles;
  - a process perspective;
  - end-to-end processes;
  - radical change;
  - evidence-based problem-solving;
  - customer centricity;
  - systems and procedures;
  - reduce process variation;
  - synchronized flow;
  - emphasize education/training;
  - perfection is the goal;
  - waste identification;
  - include everybody;
  - develop internal customer–supplier relationships.

› What are the broad approaches to managing improvement?

- What we have called 'the broad approaches to improvement' are relatively coherent collections of some of the 'elements' of improvement. The four most common are total quality management (TQM), lean, business process re-engineering (BPR) and Six Sigma.
- BPR is a typical example of the radical approach to improvement. It attempts to redesign operations along customer-focused processes rather than on the traditional functional basis. The main criticisms are that it pays little attention to the rights of staff who are the victims of the 'downsizing' which often accompanies BPR, and that the radical nature of the changes can strip out valuable experience from the operation.
- Total quality management was one of the earliest management 'fashions' and has suffered from a backlash, but the general precepts and principles of TQM are still influential. It is an approach that puts quality (and indeed improvement generally) at the heart of everything that is done by an operation.
- Lean was seen initially as an approach to be used exclusively in manufacturing, but has become seen as an approach that can be applied in service operations. Also lean, when first introduced, was radical, and counter-intuitive. The idea that inventories had a negative effect, and that throughput time was more important than capacity utilization, was difficult to accept by the more traditionally minded. So, as lean ideas have been gradually accepted, we have likewise come to be far more tolerant of ideas that are radical and/or counter-intuitive.
- Six Sigma is 'A disciplined methodology of defining, measuring, analysing, improving, and controlling the quality in every one of the company's products, processes, and transactions – with the ultimate goal of virtually eliminating all defects'. First popularized by Motorola, it was so named because it required that the natural variation of processes (± 3 standard deviations) should be half their specification range. In other words, the specification range of any part of a product or service should be ± 6 the standard deviation of the process. Now the definition of Six Sigma has widened beyond its statistical origins. It should be seen as a broad improvement concept rather than a simple examination of process variation, even though this is still an important part of process control, learning and improvement.
- There are differences between these improvement approaches. Each includes a different set of elements and therefore a different emphasis. They can be positioned on two dimensions. The first is whether the approaches emphasize a gradual, continuous approach to change or a more radical 'breakthrough' change. The second is whether the approach emphasizes *what* changes should be made or *how* changes should be made.

› What techniques can be used for improvement?

- Many of the techniques described throughout this book could be considered improvement techniques, for example statistical process control (SPC).
- Techniques often seen as 'improvement techniques' include: scatter diagrams, flow charts, cause–effect diagrams, Pareto diagrams, and why–why analysis.

CASE STUDY

GCR Insurance

'This is not going to be like last time. Then, we were adopting an improvement programme because we were told to. This time it's our idea and, if it's successful, it will be us that are telling the rest of the group how to do it.' (Tyko Mattson, Six Sigma Champion, GCR)

Source: AL RF (Alamy Images/Ingram)

Tyko Mattson was speaking as the newly appointed 'Champion' at GCR Insurance, who had been charged with '*steering the Six Sigma programme until it is firmly established as part of our ongoing practice*'. The previous improvement initiative that he was referring to dated back many years to when GCR's parent company, Wichita Mutual Insurance, had insisted on the adoption of total quality management (TQM) in all its businesses. The TQM initiative had never been pronounced a failure and had managed to make some improvements, especially in customers' perception of the company's levels of service. However, the initiative had 'faded out' during the 1990s and, even though all departments still had to formally report on their improvement projects, their number and impact were now relatively minor.

History

GCR Insurance was founded in 1922 to provide insurance for building contractors and construction companies, initially in German-speaking Europe and then in North America. In the early 1950s it started to grow partly because it moved into larger (sometimes very large) construction insurance in the industrial, oil, petrochemical and power-plant construction areas. In 1983 it absorbed the group's existing construction insurance businesses. By 2000 it had been bought by the Wichita Mutual Group and had established itself as one of the leading providers of insurance for construction projects, especially complex, high-risk projects where contractual and other legal issues, physical exposures and design uncertainty needed 'customized' insurance responses. Providing such insurance needed particular knowledge and skills from specialists including construction underwriters, loss adjusters, engineers, international lawyers, and specialist risk consultants. Typically, the company would insure losses resulting from contractor failure, related public liability issues, delays in project completion, associated litigation, other litigation (such as ongoing asbestos risks) and negligence issues.

The company's headquarters were in Geneva and housed all major departments, including sales and marketing, underwriting, risk analysis, claims and settlement, financial control, general admin, specialist and general legal advice, and business research. There were also 37 local offices around the world, organized into 4 regional areas: North America; South America; Europe Middle East and Africa; and Asia. These regional offices provided localized help and advice directly to clients and also to the 890 agents that GCR used worldwide.

The previous improvement initiative

When Wichita Mutual had insisted that CGR adopt a TQM initiative, it had gone as far as to specify exactly how it should do it and which consultants should be used to help establish the programme. Tyko Mattson shakes his head as he describes it. '*I was not with the company at that time but, looking back, it's amazing that it ever managed to do any good. You can't impose the structure of an improvement initiative from the top. It has to, at least partially, be shaped by the people who are going to be involved in it. But everything had to be done according to the handbook. The cost of quality was measured for different departments according to the handbook. Everyone had to learn the improvement techniques that were described in the handbook. Everyone had to be part of a quality circle that was organized according to the handbook. We even had to have annual award ceremonies where we gave out special "certificates of merit" to those quality circles that had achieved the type of improvement that the handbook said they should.*' The TQM initiative had been run by the 'quality committee', a group of eight people with representatives from all the major departments at head office. Initially, it had spent much of its time setting up the improvement groups and organizing training in quality techniques. However, soon it had become swamped by the work needed to evaluate which improvement suggestions

should be implemented. Soon the workload associated with assessing improvement ideas had become so great that the company decided to allocate small improvement budgets to each department on a quarterly basis that they could spend without reference to the quality committee. Projects requiring larger investment, or that had a significant impact on other parts of the business, still needed to be approved by the committee before they were implemented.

Department improvement budgets were still used within the business and improvement plans were still required from each department on an annual basis. However, the quality committee had stopped meeting a few years ago and the annual award ceremony had become a general communications meeting for all staff at the headquarters. '*Looking back*', said Tyko, '*the TQM initiate faded away for three reasons. First, people just got tired of it. It was always seen as something extra rather than part of normal business life, so it was always seen as taking time away from doing your normal job. Second, many of the supervisory and middle management levels never really bought into it, I guess because they felt threatened. Third, only a very few of the local offices around the world ever adopted the TQM philosophy. Sometimes this was because they did not want the extra effort. Sometimes, however, they would argue that improvement initiatives of this type may be OK for head office processes, but not for the more dynamic world of supporting clients in the field.*'

The Six Sigma initiative

Early in 2005 Tyko Mattson, who for the last two years had been overseeing the outsourcing of some of GCR's claims processing to India, had attended a conference on 'Operations Excellence in Financial Services', and had heard several speakers detail the success they had achieved through using a Six Sigma approach to operations improvement. He had persuaded his immediate boss, Marie-Dominique Tomas, the Head of Claims for the company, to allow him to investigate its applicability to GCR. He had interviewed a number of other financial services who had implemented Six Sigma as well as a number of consultants and in September 2005 had submitted a report entitled '*What is Six Sigma and how might it be applied in GRC?*' Extracts from this are included in Appendix 1. Marie-Dominique Tomas was particularly concerned that they should avoid the mistakes of the TQM initiative. '*Looking back, it is almost embarrassing to see how naive we were. We really did think that it would change the whole way that we did business. And although it did produce some benefits, it absorbed a large amount of time at all levels in the organization. This time we want something that will deliver results without costing too much or distracting us from focusing on business performance. That is why I like Six Sigma. It starts with clarifying business objectives and works from there.*'

By late 2005 Tyko's report had been approved both by GCR and by Wichita Mutual's main board. Tyko had been given the challenge of carrying out the recommendations in his report, reporting directly to GCR's executive board. Marie-Dominique Tomas was cautiously optimistic. '*It is quite a challenge for Tyko. Most of us on the executive board remember the TQM initiative and some are still sceptical concerning the value of such initiatives. However, Tyko's gradualist approach and his emphasis on the "three-pronged" attack on revenue, costs, and risk impressed the board. We now have to see whether he can make it work.*'

APPENDIX
Extract from '*What is Six Sigma and how might it be applied in GCR?*'

Six Sigma – pitfalls and benefits

Some pitfalls of Six Sigma

It is not simple to implement, and is resource-hungry. The focus on measurement implies that the process data is available and reasonably robust. If this is not the case it is possible to waste a lot of effort in obtaining process performance data. It may also over-complicate things if advanced techniques are used on simple problems.

It is easier to apply Six Sigma to repetitive processes – characterized by high volume, low variety and low visibility to customers. It is more difficult to apply Six Sigma to low volume, higher variety and high visibility processes where standardization is harder to achieve and the focus is on managing the variety.

Six Sigma is not a 'quick fix'. Companies that have implemented Six Sigma effectively have not treated it as just another new initiative but as an approach that requires the long-term systematic reduction of waste. Equally, it is not a panacea and should not be implemented as one.

Some benefits of Six Sigma

Companies have achieved significant benefits in reducing cost and improving customer service through implementing Six Sigma.

Six Sigma can reduce process variation, which will have a significant impact on operational risk. It is a tried and tested methodology, which combines the strongest parts of existing improvement methodologies. It lends itself to being customized to fit [each] individual company's circumstances.

For example, Mestech Assurance has extended their Six Sigma initiative to examine operational risk processes.

Six Sigma could leverage a number of current initiatives. The risk-self-assessment methodology, Sarbanes Oxley, the process library, and our performance metrics work are all laying the foundations for better knowledge and measurement of process data.

Six Sigma – key conclusions for GCR

Six Sigma is a powerful improvement methodology. It is not all new but what it does do successfully is to combine some of the best parts of existing improvement methodologies, tools and techniques. Six Sigma has helped many companies achieve significant benefits.

Six Sigma could help GCR significantly improve risk management because it focuses on driving errors and exceptions out of processes.

Six Sigma has significant advantages over other process improvement methodologies:

- It engages senior management actively by establishing process ownership and linkage to strategic objectives. This is seen as integral to successful implementation in the literature and by all companies interviewed who had implemented it.
- It forces a rigorous approach to driving out variance in processes by analysing the root cause of defects and errors and measuring improvement.
- It is an 'umbrella' approach, combining all the best parts of other improvement approaches.

Implementing Six Sigma across GCR is not the right approach

Companies who are widely quoted as having achieved the most significant headline benefits from Six Sigma were already relatively mature in terms of process management. Those companies, who understood their process capability, typically had achieved a degree of process standardization and had an established process improvement culture.

Six Sigma requires significant investment in performance metrics and process knowledge. GCR is probably not yet sufficiently advanced. However, we are working towards a position where key process data are measured and known and this will provide a foundation for Six Sigma.

A targeted implementation is recommended because:

Full implementation is resource-hungry. Dedicated resource and budget for implementation of improvements is required. Even if the approach is modified, resource and budget will still be needed, just to a lesser extent. However, the evidence is that the investment is well worth it and pays back relatively quickly.

There was strong evidence from companies interviewed that the best implementation approach was to pilot Six Sigma, and select failing processes for the pilot. In addition, previous internal piloting of implementations has been successful in GCR – we know this approach works within our culture.

Six Sigma would provide a platform for GSR to build on and evolve over time. It is a way of leveraging the ongoing work on processes, and the risk methodology (being developed by the Operational Risk Group). This diagnostic tool could be blended into Six Sigma, giving GCR a powerful model to drive reduction in process variation and improved operational risk management.

Recommendations

It is recommended that GCR management implement a Six Sigma pilot. The characteristics of the pilot would be as follows:

- A tailored approach to Six Sigma that would fit GCR's objectives and operating environment. Implementing Six Sigma in its entirety would not be appropriate.
- The use of an external partner: GCR does not have sufficient internal Six Sigma, so, external experience will be critical to tailoring the approach, and providing training.
- Establishing where GCR's Sigma performance is now. Different tools and approaches will be required to advance from 2 to 3 Sigma than those required to move from 3 to 4 Sigma.
- Quantifying the potential benefits. Is the investment worth making? What would a 1 Sigma increase in performance vs. risk be worth to us?
- Keeping the methods simple, if simple will achieve our objectives. As a minimum for us that means Team Based Problem Solving and basic statistical techniques.

Next steps

1 Decide priority and confirm budget and resourcing for initial analysis to develop a Six Sigma risk improvement programme in 2006.
2 Select external partner experienced in improvement and Six Sigma methodologies.
3 Assess GCR current state to confirm where to start in implementing Six Sigma.
4 Establish how much GCR is prepared to invest in Six Sigma and quantify the potential benefits.
5 Tailor Six Sigma to focus on risk management.
6 Identify potential pilot area(s) and criteria for assessing its suitability.
7 Develop a Six Sigma pilot plan.
8 Conduct and review the pilot programme.

QUESTIONS

1 How does the Six Sigma approach seem to differ from the TQM approach adopted by the company almost 20 years ago?

2 Is Six Sigma a better approach for this type of company?

3 Do you think Tyko can avoid the Six Sigma initiative suffering the same fate as the TQM initiative?

PROBLEMS AND APPLICATIONS

MyOMLab

These problems and applications will help to improve your analysis of operations. You can find more practice problems as well as worked examples and guided solutions on MyOMLab at **www.myomlab.com**.

1 Sophie was sick of her daily commute. 'Why', she thought 'should I have to spend so much time in a morning stuck in traffic listening to some babbling halfwit on the radio? We can work flexi-time after all. Perhaps I should leave the apartment at some other time?' So resolved, Sophie deliberately varied her time of departure from her usual 8.30. Also, being an organized soul, she recorded her time of departure each day and her journey time. Her records are shown in Table 18.1.

(a) Draw a scatter diagram that will help Sophie decide on the best time to leave her apartment.

(b) How much time per (5 day) week should she expect to be saved from having to listen to a babbling halfwit?

Table 18.1 Sophie's journey times (in minutes)

Day	*Leaving time*	*Journey time*	*Day*	*Leaving time*	*Journey time*	*Day*	*Leaving time*	*Journey time*
1	7.15	19	6	8.45	40	11	8.35	46
2	8.15	40	7	8.55	32	12	8.40	45
3	7.30	25	8	7.55	31	13	8.20	47
4	7.20	19	9	7.40	22	14	8.00	34
5	8.40	46	10	8.30	49	15	7.45	27

2 The Printospeed Laser printer company was proud of its reputation for high-quality products and services. Because of this it was especially concerned with the problems that it was having with its customers returning defective toner cartridges. About 2,000 of these were being returned every month. Its European service team suspected that not all the returns were actually the result of a faulty product, which is why the team decided to investigate the problem. Three major problems were identified. First, some users were not as familiar as they should have been with the correct method of loading the cartridge into the printer, or in being able to solve their own minor printing problems. Second, some of the dealers were also unaware of how to sort out minor problems. Third, there was clearly some abuse of Printospeed's 'no-questions-asked' returns policy. Empty toner cartridges were being sent to unauthorized refilling companies who would sell the refilled cartridges at reduced prices. Some cartridges were being refilled up to five times and were understandably wearing out. Furthermore, the toner in the refilled cartridges was often not up to Printospeed's high quality standards.

(a) Draw a cause–effect diagram that includes both the possible causes mentioned, and any other possible causes that you think worth investigating.

(b) What is your opinion of the alleged abuse of the 'no-questions-asked' returns policy adopted by Printospeed?

3 Think back to the last product or service failure that caused you some degree of inconvenience. Draw a cause–effect diagram that identifies all the main causes of why the failure could have occurred. Try to identify the frequency with which such causes happen. This could be done by talking with the staff of the operation that provided the service. Draw a Pareto diagram that indicates the relative frequency of each cause of failure. Suggest ways in which the operation could reduce the chances of failure.

SELECTED FURTHER READING

George, M.L., Rowlands, D. and Kastle, B. (2003) *What Is Lean Six Sigma?* McGraw-Hill Professional, New York. Very much a quick introduction on what Lean Six Sigma is and how to use it.

Goldratt, E.M. and Cox, J. (2004) *The Goal: A Process of Ongoing Improvement,* Gower, Aldershot. Updated version of a classic.

Hendry, L. and Nonthaleerak, P. (2004) Six Sigma: literature review and key future research areas, Lancaster University Management School, Working Paper, 2005/044 http://www.lums.lancs.ac.uk/publications/. Good overview of the literature on Six Sigma.

Hindo, B. (2007) At 3M, a struggle between efficiency and creativity: how CEO George Buckley is managing the yin and yang of discipline and imagination, *Business Week*, June 2011. Readable article from the popular business press.

Pande, P.S., Neuman, R.P. and Cavanagh, R. (2002) *Six Sigma Way Team Field Book: An Implementation Guide for Project Improvement Teams,* McGraw-Hill Professional, New York. Obviously based on the Six Sigma principle (and related to the book by the same author team recommended in Chapter 17), this is a unashamedly practical guide to the Six Sigma approach.

Paper, D.J., Rodger, J.A. and Pendharkar, P.C. (2001) A BPR case study at Honeywell, *Business Process Management Journal,* vol. 7, no. 2, 85–99. Interesting, if somewhat academic, case study.

Xingxing Zu , Fredendall, L.D. and Douglas, T.J. (2008) The evolving theory of quality management: the role of Six Sigma, *Journal of Operations Management*, 26, 630–650. As it says . . .

USEFUL WEBSITES

www.processimprovement.com Commercial site but some content that could be useful.

www.kaizen-institute.com Professional institute for kaizen. Gives some insight into practitioner views.

www.mxawards.org The Manufacturing Excellence Awards site. Dedicated to rewarding excellence and best practice in UK manufacturing. Obviously manufacturing biased, but some good examples.

www.ebenchmarking.com Benchmarking information.

www.quality.nist.gov American National Institute of Standards and Technology. Well-established institution for all types of business quality assurance.

www.balancedscorecard.org Site of an American organization with plenty of useful links.

www.myomlab.com Test which sections you have mastered and which you need to review, with questions, a personalized study plan, video clips, revision tips, and cases.

www.opsman.org Useful materials.

http://operationsroom.wordpress.com/ Stanford University's take on topical operations stories.

www.poms.org A US academic society for production and operations management. Academic, but some useful material, including a link to an encyclopedia of operations management terms.