

Chapter 6

Qualitative Process Analysis

Quality is free, but only to those who are willing to pay heavily for it.

Tom DeMarco (1940–)

Analyzing business processes is both an art and a science. In this respect, qualitative analysis is the artistic side of process analysis. Like fine arts, such as painting, there is not a single way of producing a good process analysis, but rather a range of principles and techniques that tell us what practices typically lead to a “good” process analysis. When learning to paint, you learn how to hold the brush, how to produce different types of brushstroke, how to mix colors, etc. The rest of the art of painting is up to you to acquire by means of practice, discernment and critical self-assessment.

In this chapter, we introduce a few basic principles and techniques for qualitative process analysis. First, we present principles aimed at making the process leaner by identifying unnecessary parts of the process in view of their elimination. Next, we present techniques to identify and analyze the weak parts of the process, meaning the parts that create issues that negatively affect the performance of the process. In particular, we discuss how to analyze the impact of issues in order to prioritize redesign efforts.

6.1 Value-Added Analysis

Value-added analysis typically consists of two stages: value classification and waste elimination. Below we discuss each of these stages in turn.

6.1.1 Value Classification

Value-added analysis is a technique aimed at identifying unnecessary steps in a process in view of eliminating them. In this context, a *step* may be a task in the process, or part of a task, or a handover between two tasks. For example, if a task “Check

purchase order” ends with the Purchase Order (PO) being sent by internal mail to a supervisor, and the next task “Approve purchase order” starts when the supervisor receives and checks the PO, then we can say that the transportation of the PO via internal mail is a step—a potentially unnecessary (non-value-adding) step in this context. It is often the case that one task involves several steps. For example, a task “Check invoice” may involve the following steps:

1. Retrieve the PO(s) that corresponds to the invoice.
2. Check that the amounts in the invoice and those in the PO coincide.
3. Check that the products or services referenced in the PO have been delivered.
4. Check that the supplier’s name and banking details in the invoice coincide with those recorded in the Supplier Management System.

In some cases, steps within a task are documented in the form of checklists. The checklists tell the process participants what things need to be in place before a task is considered to be complete. If detailed checklists are available, the process analyst can use them to decompose tasks into steps. Unfortunately, such checklists are not always available. In many cases, process participants have an implicit understanding of the steps in a task because they perform the task day in and day out. But this implicit understanding is not documented anywhere. In the absence of such documentation, the process analyst needs to decompose each task into steps by means of observation and interviewing.

Having decomposed the process into steps, a second prerequisite for value-added analysis is to identify who is the customer of the process and what are the positive outcomes that the customer seeks from the process (cf. Sect. 1.2). These outcomes are said to add value to the customer, in the sense that fulfilling these outcomes is in the interest or for the benefit of the customers.

Having decomposed the process into steps and having clearly identified the positive outcomes of a process, we can then analyze each step in terms of the value it adds. Steps that directly contribute to positive outcomes are called *value-adding steps*. For example, consider a process for repairing a washing machine or other domestic appliance. The steps in this process where the technician diagnoses the problem with the machine are clearly value-adding, as it directly contributes to the outcome the customer wishes to see, that is, that the machine is repaired. Also, the steps related to repairing the machine are value-adding.

Some steps do not directly add value to the customer but they are necessary for the business. Consider again the example of a process for repairing a washing machine. Imagine that this process includes a step “Record defect” in which the technician enters data about the washing machine and an explanation of the defect found in a washing machine into an information system. This step per se is not value-adding for the customer. The customer wishes the machine to be fixed and does not get value by the fact that the defect in their machine was recorded in an information system of the repairing company. However, recording defects and their resolution helps the company to build up a knowledge base of typical defects and their resolution. This knowledge base is extremely valuable when new technicians are recruited in the company, since they can learn from knowledge that more experienced technicians have recorded. Also, such information allows the company to

detect frequent defects and to report such defects to the manufacturer or distributor of the washing machine. Steps such as “Record defect” are termed *business value-adding steps*, in the sense that the customer is not willing to pay for the performance of these steps nor do they gain satisfaction from these steps being performed (so the steps are not value-adding) but the step is necessary or useful to the company that performs the process.

In summary, value-added analysis is a technique whereby an analyst decorticates a process model, extracts every step in the process and classifies these steps into one of three categories, namely:

- Value-adding (VA): This is a step that produces value or satisfaction vis-à-vis of the customer. When determining whether or not a step is value-adding, it may help to ask the following question: Would the customer be willing to pay for this activity?
- Business value-adding (BVA): The step is necessary or useful for the business to run smoothly, or it is required due to the regulatory environment of the business.
- Non-value adding (NVA): The step does not fall into any of the other two categories.

Example 6.1 We consider the process for equipment rental described in Example 1.1 (p. 2). As discussed in Sect. 1.2, the customer of this process is the site engineer who submits an equipment rental request. From the perspective of the site engineer, the positive outcome of the process is that the required piece of equipment is available in the construction site when needed. Let us analyze the fragment of this process described in Fig. 1.6. To identify the relevant steps, we will decorticate the model task by task. While we do this, we will also classify the steps into VA, BVA and NVA.

- The first task in the process model is the one where the engineer lodges the request. From the description in Example 1.1, we observe there are three steps in this task:
 1. Site engineer fills in the request.
 2. Site engineer sends the request to the clerk via e-mail (handover step).
 3. Clerk opens and reads the request (handover step).

Arguably, filling the request is value-adding insofar as the site engineer cannot expect the equipment to be rented if they do not ask for it. In one way or another, the site engineer has to request the equipment in order to obtain it. On the other hand, the site engineer does not get value out of sending the request to the clerk by e-mail nor do they get value out of the clerk having to open and read the request. More generally, handover steps between process participants, such as sending and receiving internal messages, are not value-adding.

- The second task is the one where the clerk selects a suitable equipment from the supplier’s catalog. We can treat this task as a single step. This step is value-adding insofar as it contributes to identifying a suitable equipment to fulfill the needs of the site engineer.

- In the third task, the clerk calls the supplier to check the availability of the selected equipment. Again, we can treat this task as a single step. This step is value-adding insofar as it contributes to identifying a suitable and available equipment. If the equipment is available, the clerk will recommend that this equipment be rented. To this end, the clerk adds the details of the recommended equipment and supplier to the rental request form and forwards the form to the works engineer for approval. Thus we have two more steps: (i) adding the details to the rental request and (ii) forwarding the rental request to the works engineer. The first of these steps is business value-adding since it helps the company to keep track of the equipment they rent and the suppliers they rent from. Maintaining this information is valuable when it comes to negotiating or re-negotiating bulk agreements with suppliers. The handover between the clerk and the works engineer is not value-adding.
- Next, the works engineer examines the rental request in view of approving it or rejecting it. We can treat this examination as one step. This step is a *control step*, that is, a step where a process participant or a software application checks that something has been done correctly. In this case, this control step helps the company to ensure that equipment is only rented when it is needed and that the expenditure for equipment rental in a given construction project stays within the project's budget. Control steps are generally business value-adding, although an analyst may ask the question of how many control steps are needed and how often they should be performed.
- If the works engineer has an issue with the rental request, the works engineer communicates it to the clerk or the site engineer. This communication is another step and it is business value-adding since it contributes to identifying and avoiding misunderstandings within the company. If approved, the request is sent back to the clerk; this is a handover step and it is thus non-value-adding.
- Finally, assuming the request is approved, the clerk produces and sends the PO. Here we can identify two more steps: produce the PO and send the PO to the corresponding supplier. Producing the PO is business value-adding. It is necessary in order to ensure that the rental request cost is correctly accounted for and eventually paid for. Sending the PO is value-adding: It is this act that makes the supplier know when the equipment has to be delivered on a given date. If the supplier did not get this information, the equipment would not be delivered. Note, however, that what is value-adding is the fact that the supplier is explicitly requested by the construction company to deliver the equipment on a given date. The fact that this request is made by sending a PO is secondary in terms of adding value to the site engineer.

The identified steps and their classification are summarized in Table 6.1.

Classifying steps into VA, BVA and NVA is to some extent subjective and depends on the context. For example, one may question whether producing the PO is a VA or a BVA step. Arguably, in order for the equipment to be available, the supplier needs to have an assurance that the equipment rental fee will be paid. So one could say that the production of the PO contributes to the rental of the equipment

Table 6.1 Classification of steps in the equipment rental process

Step	Performer	Classification
Fill request	Site engineer	VA
Send request to clerk	Site engineer	NVA
Open and read request	Clerk	NVA
Select suitable equipment	Clerk	VA
Check equipment availability	Clerk	VA
Record recommended equipment & supplier	Clerk	VA
Forward request to works engineer	Clerk	VA
Open and examine request	Works engineer	BVA
Communicate issues	Works engineer	BVA
Forward request back to clerk	Works engineer	NVA
Produce PO	Clerk	BVA
Send PO to supplier	Clerk	BVA

since the PO serves to assure the supplier that the payment for the rental equipment will be made. However, as mentioned above, what adds value to the site engineer is the fact that the supplier is notified that the equipment should be delivered at the required date. Whether this notification is done by means of a PO or by means of a simple electronic message sent to the supplier is irrelevant, so long as the equipment is delivered. Thus, producing a formal document (a formal PO) is arguably not value-adding. It is rather a mechanism to ensure that the construction company's financial processes run smoothly and to avoid disputes with suppliers, e.g. avoiding the situation where a supplier delivers a piece of equipment that is not needed and then asks for payment of the rental fee. More generally, we will take the convention that steps imposed by accounting or legal requirements are BVA, even though one could argue differently in some cases.

Exercise 6.1 Consider the process for university admission described in Exercise 1.1 (p. 4). What steps can you extract from this process? Classify these steps into VA, BVA and NVA.

6.1.2 Waste Elimination

Having identified and classified the steps of the process as discussed above, one can then proceed to determining how to eliminate waste. A general rule is that one should strive to minimize or eliminate NVA steps. Some NVA steps can be eliminated by means of automation. This is the case of handovers for example, which can be eliminated by putting in place an information system that allows all stakeholders to know what they need to do in order to move forward the rental requests. When

the site engineer submits a rental request via this information system, the request would automatically appear in the to-do list of the clerk. Similarly, when the clerk records the recommended supplier and equipment, the works engineer would be notified and directed to the request. This form of automation makes these NVA steps transparent to the performers of the steps. The topic of process automation will be discussed in further detail in Chap. 9.

A more radical approach to eliminating NVA steps in the working example is to eliminate the clerk altogether from the process. This means moving some of the work to the site engineer so that there are less handovers in the process. Of course, the consequences of this change in terms of added workload to the site engineer need to be carefully considered. Yet another approach to eliminate NVA (and BVA) steps would be to eliminate the need for approval of rental requests in cases where the estimated cost is below a certain threshold. Again, this option should be weighted against the possible consequences of having less control steps in place. In particular, if the site engineers were given full discretion to rent equipment at their own will, there would need to be a mechanism in place to make them accountable in case they rent unnecessary equipment or they rent equipment for excessively and unnecessarily long periods. Such process redesign questions will be further discussed in Chap. 8.

While elimination of NVA steps is generally considered a desirable goal, elimination of BVA steps should be considered as a trade-off given that BVA steps play a role in the business. Prior to eliminating BVA steps, one should first map BVA steps to business goals and business requirements, such as regulations that the company must comply to and risks that the company seeks to minimize. Given a mapping between BVA steps on the one hand and business goals and requirements on the other, the question then becomes the following: What is the minimum amount of work required in order to perform the process to the satisfaction of the customer, while fulfilling the goals and requirements associated to the BVA steps in the process? The answer to this question is a starting point for process redesign.

6.2 Root Cause Analysis

When analyzing a business process, it is worth keeping in mind that “even a good process can be made better” [28]. Experience shows that any non-trivial business process, no matter how much improvement it has undergone, suffers from a number of issues. There are always errors, misunderstandings, incidents, unnecessary steps and other forms of waste when a business process is performed on a day-to-day basis.

Part of the job of a process analyst is to identify and to document the *issues* that plague a process. To this end, an analyst will typically gather data from multiple sources and will interview several stakeholders, chiefly the process participants but also the process owner and managers of organizational units involved in the process. Each stakeholder has a different view on the process and will naturally have a tendency to raise issues from their own perspective. The same issue may be perceived

differently by two stakeholders. For example, an executive manager or a process owner will typically see issues in terms of performance objectives not being met or in terms of constraints imposed for example by external pressures (e.g. regulatory or compliance issues). Meanwhile, process participants might complain about insufficient resources, hectic timelines as well as errors or exceptions perceived to be caused by other process participants or by customers.

Root cause analysis is a family of techniques to help analysts identify and understand the root cause(s) of problems or undesirable events. Root cause analysis is not confined to business process analysis. In fact, root cause analysis is commonly used in the context of accident or incident analysis as well as in manufacturing processes where it is used to understand the root cause of defects in a product. In the context of business process analysis, root cause analysis is helpful to identify and to understand the issues that prevent a process from having a better performance.

Root cause analysis encompasses a variety of techniques. In general, these methods include guidelines for interviewing and conducting workshops with relevant stakeholders, as well as techniques to organize and to document the ideas generated during these interviews or workshops. Below, we will discuss two of these techniques, namely *cause-and-effect diagrams* and *why-why diagrams*.

6.2.1 Cause–Effect Diagrams

Cause–effect diagrams depict the relationship between a given *negative effect* and its causes. In the context of process analysis, a negative effect is usually either a recurrent issue or an undesirable level of process performance. Causes can be divided into causal and contributing factors (hereby called *factors*) as explained in the box below.

CAUSAL VERSUS CONTRIBUTING FACTORS

Two broad types of cause are generally distinguished in the area of root cause analysis, namely *causal factors* and *contributing factors*. Causal factors are those factors that, if corrected, eliminated or avoided would prevent the issue from occurring in future. For example, in the context of an insurance claims handling process, errors in the estimation of damages lead to incorrect claim assessments. If the damage estimation errors were eliminated, a number of occurrences of the issue “Incorrect claim assessment” would definitely be prevented. Contributing factors are those that set the stage for, or that increase the chances of a given issue occurring. For example, consider the case where the user interface for lodging the insurance claims requires the claimant to enter a few dates (e.g. the date when the claim incident occurred), but the interface does not provide a calendar widget so that the user can easily select the date. This deficiency in the user interface may increase the chances that

the user enters the wrong date. In other words, this deficiency contributes to the issue “Incorrect claim data entry”.

While the distinction between causal and contributing factor is generally useful when investigating specific incidents (for example investigating the causes of a given road accident), the distinction is often not relevant or not sufficiently sharp in the context of business process analysis. Accordingly, in this chapter we will use the term *factor* to refer to causal and contributing factors collectively.

In a cause–effect diagram, factors are grouped into categories and possibly also sub-categories. These categories are useful in order to guide the search for causes. For example, when organizing a brainstorming session for root cause analysis, one way to structure the session is to first go around the table asking each participant to give their opinion on possible causes of the issue at hand. The causes are first written down in any order. Next, the identified causes are classified according to certain categories and the discussion continues in a more structured way using these categories as a framework.

A well-known categorization for cause–effect analysis are the so-called 6M’s, which are described below together with possible sub-categorizations.

1. **Machine** (technology)—factors pertaining to the technology used, like for example software failures, network failures or system crashes that may occur in the information systems that support a business process. A useful sub-categorization of Machine factors is the following:
 - a. Lack of functionality in application systems.
 - b. Redundant storage of data across systems, leading for example to double data entry (same data entered twice in different systems) and data inconsistencies across systems.
 - c. Low performance of IT of network systems, leading for example to low response times for customers and process participants.
 - d. Poor user interface design, leading for example to customers or process participants not realizing that some data are missing or that some data are provided but not easily visible.
 - e. Lack of integration between multiple systems within the enterprise or with external systems such as a supplier’s information system or a customer’s information system.
2. **Method** (process)—factors stemming from the way the process is defined or understood or in the way it is performed. An example of this is when a given process participant A thinks that another participant B will send an e-mail to a customer, but participant B does not send it because they are not aware they have to send it. Possible sub-categories of Method factors include:
 - a. Unclear, unsuitable or inconsistent assignment of decision-making and processing responsibilities to process participants.

- b. Lack of empowerment of process participants, leading to process participants not being able to make necessary decisions without consulting several levels above in their organizational hierarchy. Conversely, excessive empowerment may lead to process participants having too much discretion and causing losses to the business through their actions.
 - c. Lack of timely communication between process participants or between process participants and the customer.
3. **Material**—factors stemming from the raw materials, consumables or data required as input by the activities in the process, like for example incorrect data leading to a wrong decision being made during the execution of a process. The distinction between raw materials, consumables and data provides a possible sub-categorization of these factors.
 4. **Man**—factors related to a wrong assessment or an incorrectly performed step, like for example a claims handler accepting a claim even though the data in the claim and the rules used for assessing the claim require that the claim be rejected. Possible sub-categories of Man factors include:
 - a. Lack of training and clear instructions for process participants.
 - b. Lack of incentive system to motivate process participants sufficiently.
 - c. Expecting too much from process participants (e.g. overly hectic schedules).
 - d. Inadequate recruitment of process participants.
 5. **Measurement**—factors related to measurements or calculations made during the process. In the context of an insurance claim, an example of such a factor is one where the amount to be paid to the customer is miscalculated due to an inaccurate estimation of the damages being claimed.
 6. **Milieu**—factors stemming from the environment in which the process is executed, like for example factors originating from the customer, suppliers or other external actors. Here, the originating actor is a possible sub-categorization. Generally, milieu factors are outside the control of the process participants, the process owner, and other company managers. For example, consider a process for handling insurance claims for car accidents. This process depends partly on data extracted from police reports (e.g. police reports produced when a major accident occurs). It may happen in this context that some errors during the claims handling process originate from inaccuracies or missing details in the police reports. These factors are to some extent outside the control of the insurance company. This example illustrates that milieu factors may need to be treated differently from other (internal) factors.

These categories are meant as guidelines for brainstorming during root cause analysis rather than gospel that should be followed to the letter. Other ways of categorizing factors may be equally useful. For example, one alternative categorization is known as the 4P's (Policies, Procedures, People, and Plant/Equipment). Also, it is sometimes useful to classify factors according to the activities in the process where they originate (i.e. one category per major activity in the process). This approach allows us to easily trace the relation between factors and activities in the process.

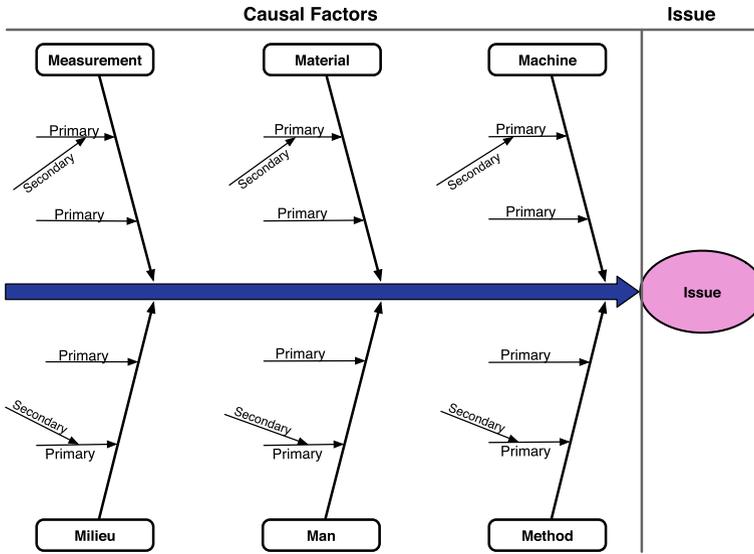


Fig. 6.1 Template of a cause–effect diagram based on the 6M’s

The above categories are useful not only as a guide for brainstorming during root cause analysis, but also as a basis for documenting the root causes in the form of a cause–effect diagram. Concretely, a cause–effect diagram consists of a main horizontal line (the *trunk*) from which a number of branches stem (cf. Fig. 6.1). At one end of the trunk is a box containing the negative effect that is being analyzed (in our case the *issue* being analyzed). The trunk has a number of main branches corresponding to the categories of factors (e.g. the 6M’s above). The root causes are written in the sub-branches. Sometimes, it is relevant to distinguish between *primary factors*, meaning factors that have a direct impact on the issue at hand, from *secondary factors*, which are factors that have an impact on the primary factors. For example, in the context of an insurance claims handling process, an inaccurate estimation of the damages leads to a miscalculation of the amount to be paid for a given claim. This inaccurate estimation of the damages may itself stem from a lack of incentive from the repairer to accurately calculate the cost of repairs. Thus, “Inaccurate damage estimation” can be seen as a primary factor for “Liability miscalculation”, while “Lack of incentive to calculate repair costs accurately” is a secondary factor behind the “Inaccurate damage estimation”. The distinction between primary and secondary factors is a first step towards identifying chains of factors behind an issue. We will see later in this chapter that why–why diagrams allow us to dig deeper into such chains of factors.

Because of their visual appearance, cause–effect diagrams are also known as *Fishbone diagrams*. Another common name for such diagrams is *Ishikawa diagrams* in allusion to one of its proponents—Kaoru Ishikawa—one of the pioneers of the field of quality management.

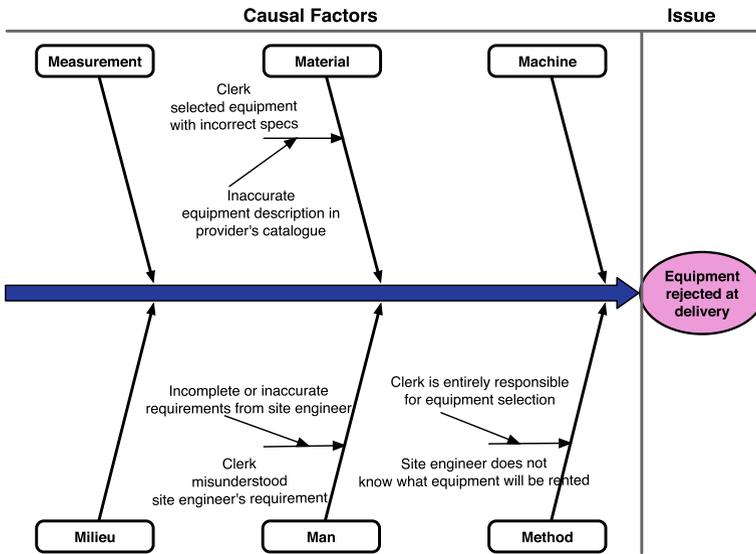


Fig. 6.2 Cause-effect diagram for issue “Equipment rejected at delivery”

Example 6.2 We consider again the equipment rental process described in Example 1.1 (p. 2). During an audit of this process, several issues were identified. It turns out that oftentimes the site engineer finds that the equipment delivered at the construction site is not suitable because it is either too small or not powerful enough for the job. Hence it has to be rejected. One clerk claims that the site engineers generally do not specify their requirements in sufficient detail. Other clerks blame the suppliers for giving inaccurate or incomplete descriptions of their equipment in their catalogs. On the other hand, site engineers complain that they are not consulted when there are doubts regarding the choice of equipment.

This scenario basically describes one issue, namely that the equipment is being rejected upon delivery. We can see three primary causes from the issue, which are summarized in the cause-effect diagram in Fig. 6.2. The diagram also shows secondary causes underpinning each of the primary causes. Note that the factor “clerk selected equipment with incorrect specs” has been classified under the Material category because this factor stems from incorrect input data. A defect in input data used by a process falls under the Material category.

Exercise 6.2 Consider the university admission process described in Exercise 1.1 (p. 4). One of the issues faced by the university is that students have to wait too long to know the outcome of the application (especially for successful outcomes). It often happens that by the time a student is admitted, the student has decided to go to another university instead (students send multiple applications in parallel to many universities). Analyze the causes of this issue using a cause-effect diagram.

6.2.2 Why–Why Diagrams

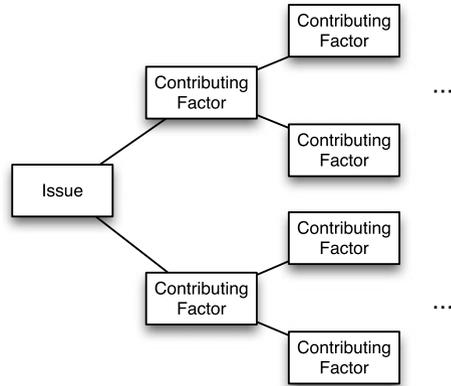
Why–why diagrams (also known as *tree diagrams*) constitute another technique to analyze the cause of negative effects, such as issues in a business process. The emphasis of root cause analysis is to capture the series of cause-to-effect relations that lead to a given effect. The basic idea is to recursively ask the question: Why has something happened? This question is asked multiple times until a factor that stakeholders perceive to be a *root cause* is found. A common belief in the field of quality management—known as the five Why’s principle—has it that answering the “why” question five times recursively allows one to pin down the root causes of a given negative effect. Of course, this should not be treated as gospel, but as a guideline of how far one should go during root cause analysis.

Why–why diagrams are a technique for structuring brainstorming sessions (e.g. workshops) for root cause analysis. Such a session would start with an issue. The first step is to give a name to the issue that stakeholders agree on. Sometimes it is found that there is not one issue, but multiple issues, in which case they should be analyzed separately. Once the issue has been identified and a name has been agreed upon, this becomes the root of the tree. Then at each level the following questions are asked: “Why does this happen?” and “What are the main sub-issues that may lead to this issue?”. Possible factors are then identified. Each of these factors is then analyzed using the same questions. When getting down in the tree (e.g. to levels 3 or 4) it is recommended to start focusing on factors that can be resolved, meaning that something can be done to change them. The leaves of the tree should correspond to factors that are fundamental in nature, meaning that they cannot be explained in terms of other factors. Ideally, these factors, called root causes, should be such that they can be eliminated or mitigated, but this is not necessarily the case. For example, in the context of an insurance claims handling process, a certain type of errors in a police report may be due to lack of time and hectic schedules on the side of police agents involved in filling these reports. There is relatively little the insurance agency can do in this case to eliminate the error, other than raising the issue with the relevant authorities. Yet, the impact of this factor could be mitigated by putting in place checks to detect such errors as early as possible in the process.

A simple template for why–why diagrams is given in Fig. 6.3. An alternative way of presenting the information in such diagrams is by means of nested bullet-point lists. In the rest of this chapter we will opt for the latter representation.

Example 6.3 We consider again the equipment rental process described in Example 1.1 (p. 2). In Example 6.2 above, we noted that one of the issues with this process is that the site engineer sometimes rejected the equipment upon delivery because it was not suitable for the job at hand. Another issue is that BuildIT spends more in equipment rental than what it budgeted for. An auditor pointed out that one of the reasons for excessive expenditure was that site engineers were keeping the rented equipment longer than initially planned by using deadline extensions. Site engineers knew that it was easy to get a deadline extension. They also knew that it took quite some time to get equipment rental requests approved, and the larger the cost and

Fig. 6.3 Template of a why-why diagram



the duration of the rental, the slower it was to get it approved. So in many cases, site engineers were renting equipment several days before the date when they actually needed it. Also, they were specifying short periods in their equipment rental requests in order to get them approved quicker. When the deadline for returning an equipment approached, they just called the supplier to keep the equipment for a longer period.

Another issue spotted by the auditor is that a significant amount of late-payment penalty fees were paid to the suppliers because invoices for equipment rental were not paid by their due date. The clerks blamed the site engineers for being slow in approving the invoices.

In summary, we can distinguish at least three issues. First, the wrong equipment is being delivered on some occasions. Secondly site engineers are frequently asking for deadline extensions. Thirdly, BuildIT is often paying late payment fees to suppliers. A possible analysis root cause analysis of these issues leads to the following why-why diagrams (represented as nested bullet-point lists).

Issue 1 Site engineers sometimes reject delivered equipment, why?

Wrong equipment is delivered, why?

- miscommunication between site engineer and clerk, why?
 - site engineer provides only brief/inaccurate description of what they want
 - site engineer does not (always) see the supplier catalogs when making a request and does not communicate with the supplier, why?
 - site engineer generally does not have Internet connectivity
 - site engineer does not check the choice of equipment made by the clerk
- equipment descriptions in supplier’s catalog not accurate

Issue 2 Site engineers keep equipment longer than needed via deadline extensions, why?

Site engineer fears that equipment will not be available later when needed, why?

- time between request and delivery too long, why?
 - excessive time spent in finding a suitable equipment and approving the request, why?
 - time spent by clerk contacting possibly multiple suppliers sequentially
 - time spent waiting for works engineer to check the requests

Issue 3 BuildIT often has to pay late payment fees to suppliers, why?

Time between invoice received by clerk and confirmation is too long, why?

- clerk needs confirmation from site engineer, why?
 - clerk cannot assert when was the equipment delivered and picked-up, why?
 - delivery and pick-up of equipments are not recorded in a shared information system
 - site engineer can extend the equipment rental period without informing the clerk
 - site engineer takes too long to confirm the invoice, why?
 - confirming invoices is not a priority for site engineer

Exercise 6.3 Consider again the process for university admission described in Exercise 1.1 (p. 4) and the issue described in Exercise 6.2 above. Analyze this issue using a why–why diagram.

6.3 Issue Documentation and Impact Assessment

Root cause analysis techniques allow us to understand the factors behind a given issue. A natural next step is to understand the impact of these issues. Building up this understanding is critical in order to prioritize the issues so that the attention of the process owner, participants and analysts can be focused on the issues that most matter to the organization. Below we discuss two complementary techniques for impact assessment.

6.3.1 Issue Register

The *issue register* complements the output of root cause analysis by providing a more detailed analysis of individual issues and their impact. The purpose of the issue register is to determine how and to what extent each issue is impacting on the performance of the process. The impact of an issue can be described quantitatively, for example in terms of time or money lost, or qualitatively, in terms of perceived nuisance to the customer or perceived risks that the issue entails. For example, nuisances caused to the customer because of misunderstandings during the execution of the process can be classified as qualitative impact, since it is difficult to translate this nuisance into a monetary measure.

Concretely, an issue register is a listing that provides a detailed analysis of each issue and its impact in the form of a table with a pre-defined set of fields. The following fields are typically described for each issue:

- *Name of the issue.* This name should be kept short, typically two–five words, and should be understandable by all stakeholders in the process.
- *Description.* A short description of the issue, typically one–three sentences, focused on the issue itself as opposed to its consequences or impact, which are described separately.
- *Priority.* A number (1, 2, 3, ...) stating how important this issue is relative to other issues. Note that multiple issues can have the same priority number.
- *Assumptions (or input data).* Any data used or assumptions made in the estimation of the impact of the issue, such as for example number of times a given negative outcome occurs, or estimated loss per occurrence of a negative outcome. In the early phases of the development of the issue register, the numbers in this column will be mainly assumptions or ballpark estimates. Over time, these assumptions and rough estimates will be replaced with more reliable numbers derived from actual data about the execution of the process.
- *Qualitative impact.* A description of the impact of the issue in qualitative terms, such as impact of the issue on customer satisfaction, employee satisfaction, long-term supplier relationships, company's reputation or other intangible impact that is difficult to quantify.
- *Quantitative impact.* An estimate of the impact of the issue in quantitative terms, such as time loss, revenue loss or avoidable costs.

Other fields may be added to an issue register. For example, in view of process redesign, it may be useful to include an attribute *possible resolution* that describes possible mechanisms for addressing the issue.

Example 6.4 We consider again the equipment rental process described in Example 1.1 (p. 2) and the issues described above in Examples 6.2 and 6.3. The issue register given in Table 6.2 provides a more detailed analysis of these issues and their impact.¹

Question Issue or factor?

An issue register is likely to contain a mixture of issues that have a direct impact on business performance, and others that are essentially causal or contributing factors of other issues that then impact on business performance. In other words, the issue register contains both issues and factors. For example, in the issue register of the equipment rental process, one could find the following entries:

- Clerk misunderstood the site engineer's requirements for an equipment.

¹In this issue register we do not use multiple columns. This is a pragmatic choice to better fit the issue register within the width of the page.

Table 6.2 Issue register of equipment rental process

Issue 1: Equipment kept longer than needed

Priority: 1

Description: Site engineers keep the equipment longer than needed by means of deadline extensions

Assumptions: BuildIT rents 3000 pieces of equipment per year. In 10 % of cases, site engineers keep the equipment two days longer than needed to avoid disruptions due to delays in equipment rentals. On average, rented equipment costs € 100 per day

Qualitative impact: Not applicable

Quantitative impact: $0.1 \times 3000 \times 2 \times \text{€ } 100 = \text{€ } 60,000$ in additional rental expenses per year

Issue 2: Rejected equipment

Priority: 2

Description: Site engineers sometimes reject the delivered equipment due to non-conformance to their specifications

Assumptions: BuildIT rents 3000 pieces of equipment per year. Each time an equipment is rejected due to a mistake on BuildIT's side, BuildIT is billed the cost of one day of rental, that is € 100. 5 % of them are rejected due to an internal mistake within BuildIT (as opposed to a supplier mistake)

Qualitative impact: These events disrupt the construction schedules and create frustration and internal conflicts

Quantitative impact: $3000 \times 0.05 \times \text{€ } 100 = \text{€ } 15,000$ per year

Issue 3: Late payment fees

Priority: 3

Description: BuildIT pays late payment fees because invoices are not paid by the due date

Assumptions: BuildIT rents 3000 pieces of equipment per year. Each equipment is rented on average for 4 days at a rate of € 100 per day. Each rental leads to one invoice. About 10 % of invoices are paid late. On average, the penalty for late payment is 2 % of the amount of the invoice

Qualitative impact: Suppliers are annoyed and later unwilling to negotiate more favorable terms for equipment rental

Quantitative impact: $0.1 \times 3000 \times 4 \times \text{€ } 100 \times 0.02 = \text{€ } 2400$ per year

- Clerk did not select the correct equipment from the supplier's catalog due to inattention.
- Clerk indicated an incorrect delivery date in the PO and the supplier used this wrong date.
- Supplier did not deliver the exact equipment that had been ordered.
- Delivered equipment is faulty or is not ready-for-use.
- Supplier delivered the equipment to the wrong construction site or at the wrong time.

All of the above issues are possible causal or contributing factors of a top-level issue, namely "Equipment is rejected by the site engineer". The fact that the site engineer rejects the equipment creates a direct impact for BuildIT, for example in

terms of delays in the construction schedule. Meanwhile, the issues listed above have an indirect business impact, in the sense that they lead to the equipment being rejected and the needed equipment not being available on time, which in turn leads to delays in the construction schedule.

When an issue register contains a combination of issues and factors, it may be useful to add two fields to the register, namely “caused by” and “is cause of”, that indicate for a given issue, which other issues in the register are related to it via a cause–effect relation. This way it becomes easier to identify which issues are related between them so that related issues can be analyzed together. Also, when an issue X is a factor of an issue Y, instead of analyzing both the impact of X and Y, we can analyze the impact of Y and in the qualitative and quantitative impact fields of X we can simply refer to the impact of Y. For example, in the impact field of issue “Clerk misunderstood the site engineer’s requirements” we can simply refer to the impact of “Equipment is rejected by the site engineer”.

Alternatively, we can adopt the convention of including in the issue register only top-level issues, meaning issues that have a direct business impact, and separately, we can use why–why diagrams and cause–effect diagrams to document the factors underpinning these top-level issues. This convention is followed in the rest of this chapter, meaning that the issue registers shown below only contain top-level issues rather than factors.

Exercise 6.4 Write an issue register for the university admission process and the issue described in Exercise 6.2.

6.3.2 Pareto Analysis and PICK Charts

The impact assessment conducted while building the issue register can serve as input for *Pareto analysis*. The aim of Pareto analysis is to identify which issues or which causal factors of an issue should be given priority. Pareto analysis rests on the principle that a small number of factors are responsible for the largest share of a given effect. In other words:

- A small subset of issues in the issue register are likely responsible for the largest share of impact.
- For a given issue, a small subset of factors behind this issue are likely responsible for the largest share of occurrences of this issue.

Sometimes this principle is also called the 80–20 principle, meaning that 20 % of issues are responsible for 80 % of the effect. One should keep in mind, however, that the specific proportions are only indicative. It may be for example that 30 % of issues are responsible for 70 % of the effect.

A typical approach to conduct Pareto analysis is as follows:

1. Define the effect to be analyzed and the measure via which this effect will be quantified. The measure might be for example:

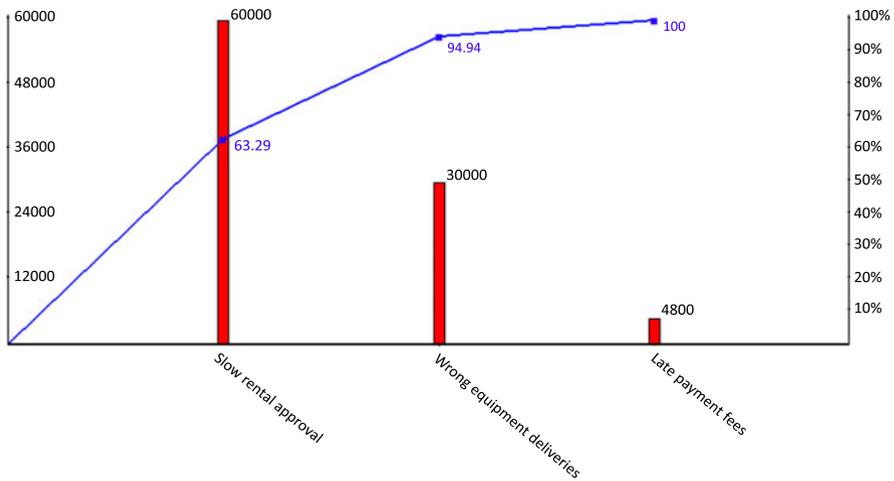


Fig. 6.4 Pareto chart for excessive equipment rental expenditure

- Financial loss for the customer or for the business.
 - Time loss by the customer or by the process participants.
 - Number of occurrences of a negative outcome, such as number of unsatisfied customers due to errors made when handling their case.
2. Identify all relevant issues that contribute to the effect to be analyzed.
 3. Quantify each issue according to the chosen measure. This step can be done on the basis of the issue register, in particular, the quantitative impact column of the register.
 4. Sort the issues according to the chosen measure (from highest to lowest impact) and draw a so-called *Pareto chart*. A Pareto chart consists of two components:
 - a. A bar chart where each bar corresponds to an issue and the height of the bar is proportional to the impact of the issue or factor.
 - b. A curve that plots the cumulative percentage impact of the issues. For example, if the issue with the highest impact is responsible for 40 % of the impact, this curve will have a point with a y-coordinate of 0.4 and an x-coordinate positioned so as to coincide with the first bar in the bar chart.

Example 6.5 Consider again the equipment rental process described in Example 1.1 (p. 2) and the issue register in Example 6.4. All three issues in this register share in common that they are responsible for unnecessary rental expenditure, which is a form of financial loss. From the data in the impact column of the register, we can plot the Pareto chart in Fig. 6.4.

This Pareto chart shows that issue “Slow rental approval” is responsible already for 63 % of unnecessary rental expenditure. Given that in this example there are only three issues, one could have come to this conclusion without conducting Pareto analysis. In practice though, an issue register may contain dozens or hundreds of issues, making Pareto analysis a useful tool to summarize the data in the issue register.

Exercise 6.5 Let us consider again the equipment rental process. This time we take the perspective of the site engineer, whose goal is to have the required equipment available on site when needed. From this perspective, the main issue is that in about 10 % of cases, the requested equipment is not available on site the day when it is required. When this happens, the site engineer contacts the suppliers directly to resolve the issue, but still, resolving the issue may take several days. It is estimated that each such delay costs € 400 per day to BuildIT. By inspecting a random sample of delayed equipment deliveries during a one-year period and investigating the cause of each occurrence, an analyst found that:

1. five occurrences were due to the site engineer not having ordered the equipment with sufficient advance notice: The site engineers ordered the equipment the day before it was needed, when at least two days are needed. These cases cause delays of one day on average.
2. nine occurrences were due to the fact that none of BuildIT's suppliers had the required type of equipment available on the requested day. These cases cause delays of one to four days (three days on average).
3. 13 occurrences were due to the approval process taking too long (more than a day) due to mistakes or misunderstandings. For these cases, the delay was one day on average.
4. 27 occurrences were due to the equipment having been delivered on time, but the equipment was not suitable and the site engineer rejected it. These cases cause delays of two days on average.
5. four occurrences were due to mistakes or delays attributable entirely to the supplier. These cases lead to delays of one day. However, in these cases, the supplier compensated BuildIT by providing the equipment two days for free (the remaining days are still charged). Recall that the average cost of an equipment rental per day is € 100.
6. For two occurrences, the analyst did not manage to determine the cause of the delay (the process participants could not recall the details). The delays in these cases were two days per occurrence.

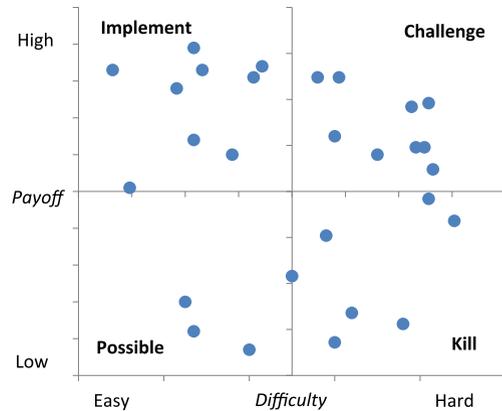
The sample of analyzed occurrences represents around 20 % of all occurrences of the issue during a one-year period.

Draw a Pareto chart corresponding to the above data.

It is worth highlighting that Pareto analysis focuses on a single dimension. In the example above, the dimension under analysis is the impact in monetary terms. In other words, we focus on the estimated payoff of addressing an issue. In addition to payoff, there is another dimension that should be taken into account when deciding which issues should be given higher priority, namely the level of difficulty of addressing an issue. This level of difficulty can be quantified in terms of the amount of investment required to change the process in order to address the issue in question.

A type of chart that can be used as a complement to Pareto charts in order to take into account the difficulty dimension is the *PICK chart*. A PICK chart (see Fig. 6.5) is a four-quadrant chart where each issue appears as a point. The horizontal axis

Fig. 6.5 PICK chart



captures the difficulty of addressing the issue (or more specifically the difficulty of implementing a given improvement idea that addresses the issue) while the vertical axis captures the payoff. The horizontal axis (difficulty) is split into two sections (easy and hard) while the vertical axis (payoff) is split into low and high. These splits lead to four quadrants that allow analysts to classify issues according to the trade-off between payoff and difficulty:

- *Possible* (low payoff, easy to do): issues that can be addressed if there are sufficient resources for doing so.
- *Implement* (high payoff, easy to do): issues that should definitely be implemented as a matter of priority.
- *Challenge* (high payoff, hard to do): issues that should be addressed but require significant amount of effort. In general one would pick one of these challenges and focus on it rather than addressing all or multiple challenges at once.
- *Kill* (low payoff, hard to do): issues that are probably not worth addressing or at least not to their full extent.

6.4 Recap

In this chapter, we presented a selection of techniques for qualitative analysis of business processes. The first presented technique, namely value-added analysis, aims at identifying waste, specifically time wasted in activities that do not give value to the customer or to the business. Next, we presented two techniques to uncover the causes of issues that affect the performance of a process, namely cause–effect analysis and why–why analysis. Whereas cause–effect analysis focuses on classifying the factors underpinning the occurrences of an issue, why–why analysis focuses on identifying the recursive cause–effect relations between these factors.

Finally, we presented an approach to systematically document issues in a process, namely the issue register. The purpose of an issue register is to document issues

in a semi-structured way and to analyze their impact on the business both from a qualitative and a quantitative angle. In particular, the issue register provides a starting point to build Pareto charts and PICK charts—two visualization techniques that provide a bird’s-eye view of a set of issues. These charts help analysts to focus their attention on issues that offer the best payoff (in the case of Pareto charts) or the best trade-off between payoff and difficulty (in the case of PICK charts).

6.5 Solutions to Exercises

Solution 6.1

- VA: receive online application, evaluate academic admissibility, send notification to student.
- BVA: check completeness, academic recognition agency check, English test check.
- NVA: receive physical documents from students, forward documents to committee, notify students service of outcomes of academic admissibility.

Note In this solution we treat the entire agency check as BVA. Part of this agency check consists of the admissions office sending the documents to the agency and the agency sending back the documents and their assessment to the admissions office. These two sub-steps could be treated as NVA. However, if we assume that the agency requires the documents to be sent by post to them, these sub-steps cannot be easily separated from the agency check itself. In other words, it would not be possible to eliminate these handover steps without eliminating the entire agency check. Thus the entire agency check should arguably be treated as a single step.

Solution 6.2 The cause–effect diagram corresponding to this exercise should include at least the name of the issue (e.g. “Student waiting time too long”) and the following factors:

- Process stalls due to agency check. This is a “Method” issue, since the issue stems from the fact that the process essentially stalls until a response is received from the agency. One could argue that to some extent this is a “Milieu” issue. But while the slowness of the agency check is a “Milieu” issue, the fact that the process stalls until a response is received from the agency is a “Method” issue.
- Agency check takes too long. This is a “Milieu” issue since the agency is a separate entity that imposes its own limitations.
- Academic committee assessment takes too long. This is a “Method” issue since the process imposes that the academic committee only assesses applications at certain times (when it meets), rather than when applications are ready to be evaluated.
- Physical documents take too long to be received. This is a “Milieu” issue for two reasons. First, the physical documents are needed for the purpose of the agency

check and the delays in the arrival of physical documents are caused by the applicants themselves and postal service delays.

- Admission office delays the notification after academic assessment. This seems to be a “Method” issue, but the description of the process does not give us sufficient information to state this conclusively. Here, a process analyst would need to gather more information in order to understand this issue in further detail.

Solution 6.3

Admission process takes too long, why?

- Process stalls until physical documents arrive, why?
 - Agency check requires physical documents.
 - Other tasks are performed only after agency check, why?
 - Traditionally this is how the process is set-up but there is no strong reason for it.
- Agency check takes too long, why?
 - Exchanges with the agency are via post, why?
 - Agency requires original (or certified) documents due to regulatory requirements.

Academic committee takes too long, why?

- Documents are exchanged by internal mail between admissions office and committee.
- Academic committee only meets at specified times.

Admission office delays the notification after academic assessment, why?

- Not enough information available to analyze this issue (probably due to batching —admissions office sends notifications in batches).

The above analysis already suggests one obvious improvement idea: perform the academic committee assessment in parallel to the agency check. Another improvement opportunity is to replace internal mail communication between admissions office and academic committee with electronic communication (e.g. documents made available to committee members via a Web application).

Note that we could have done the analysis starting from the issue “Admitted students reject their admission offer”. This might be useful since there might be several reasons why students reject their offer, some related to the admission process, but also some unrelated to the process.

Solution 6.4 In the following issue register, we only analyze the issue described in this chapter, namely that the admission process takes too long. In practice, the issue register would include multiple issues.

Issue 1: Students reject offer due to long waiting times**Priority: 1****Description:** The time between online submission of an application to notification of acceptance takes too long, resulting in some students rejecting their admission offer**Assumptions:** Circa 20 students per admission round reject their offer because of the delays. Assessment of each application costs € 100 per student to the university in time spent by admissions office and academic committee, plus an additional € 50 for the agency check. University spends € 100 in marketing for each application it attracts**Qualitative impact:** Students who would contribute to the institution in a positive way are lost. Delays in the admission process affect the image of the university vis-a-vis of future students, and generate additional effort to handle enquiries from students while they wait for the admission decisions**Quantitative impact:** $20 \times \text{€ } 250 = \text{€ } 5000$ per admission round

In the above issue analysis, the effort required to deal with enquiries during the pre-admission period is listed in the qualitative impact field. If it was possible (with a reasonable amount of effort) to estimate how many such enquiries arrive and how much time they consume, it would be possible to turn this qualitative impact into a quantitative one.

Solution 6.5 First, we analyze the cost incurred by each type of occurrence (i.e. each causal factor) in the sample:

1. Last-minute request: one day delay (because normally two days advance notice are needed), thus $\text{€ } 400 \text{ cost} \times 5 = \text{€ } 2000$.
2. Equipment out-of-stock: three days delay = $\text{€ } 1200 \times 9 = \text{€ } 10,800$.
3. Approval delay: one day delay = $\text{€ } 400 \times 13 = \text{€ } 5200$.
4. Rejected equipment: two days delay = $\text{€ } 800 \times 27 = \text{€ } 21,600$. Note that in Example 6.4 we mentioned that when an equipment is rejected, a fee of € 100 (on average) has to be paid to the supplier for taking back the equipment. However, we do not include this fee here because we are interested in analyzing the costs stemming from equipment not being available on the required day, as opposed to other costs incurred by rejecting equipments.
5. Supplier mistake: one day delay = $\text{€ } 400$ minus $\text{€ } 200$ in rental cost saving = $\text{€ } 200 \times 4 = \text{€ } 800$.
6. Undetermined: two days delay = $\text{€ } 800 \times 2 = \text{€ } 1600$.

Since the sample represents 20 % of occurrences of the issue over a year, we multiply the above numbers by five in order to estimate the total yearly loss attributable to each causal factor. The resulting Pareto chart is given in Fig. 6.6.

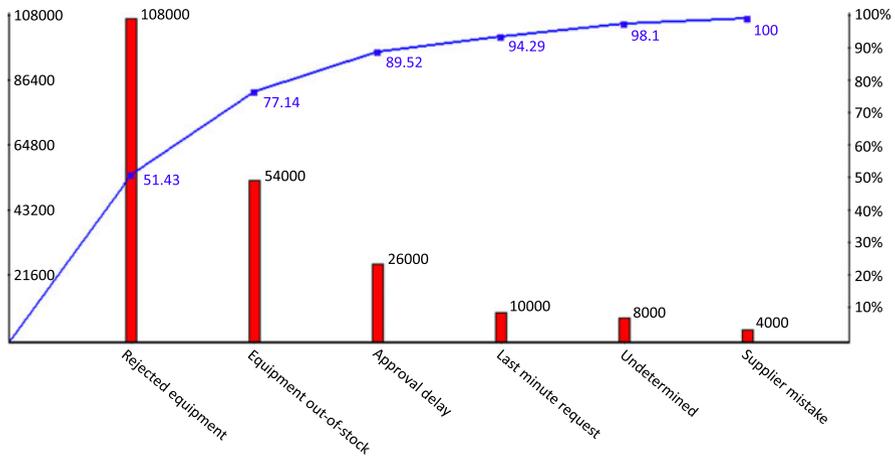


Fig. 6.6 Pareto chart of causal factors of issue “Equipment not available when needed”

6.6 Further Exercises

Exercise 6.6 Consider the following summary of issues reported in a travel agency.

A travel agency has recently lost several medium-sized and large corporate customers due to complaints about poor customer service. The management team of the travel agency decided to appoint a team of analysts to address this problem. The team gathered data by conducting interviews and surveys with current and past corporate customers and also by gathering customer feedback data that the travel agency has recorded over time. About 2 % of customers complained about errors that had been made in their bookings. In one occasion, a customer had requested a change to a flight booking. The travel agent wrote an e-mail to the customer suggesting that the change had been made and attached a modified travel itinerary. However, it later turned out that the modified booking had not been confirmed in the flight reservation system. As a result, the customer was not allowed to board the flight and this led to a series of severe inconveniences for the customer. Similar problems had occurred when booking a flight initially: the customer had asked for certain dates, but the flight tickets had been issued for different dates. Additionally, customers complained of the long times it took to get responses to their requests for quotes and itineraries. In most cases, employees of the travel agency replied to requests for quotes within 2–4 working hours, but in the case of some complicated itinerary requests (about 10 % of the requests), it took them up to 2 days. Finally, about 5 % of customers also complained that the travel agents did not find the best flight connections and prices for them. These customers essentially stated that they had found better itineraries and prices on the Web by searching by themselves.

1. Analyze the issues described above using root cause analysis techniques.
2. Document the issues in the form of an issue register. To this end, you may assume that the travel agency receives around 100 itinerary requests per day and that the agency makes 50 bookings per day. Each booking brings a gross profit of € 100 to the agency.

Exercise 6.7 Consider the pharmacy prescription fulfillment process described in Exercise 1.6 (p. 28). Identify the steps in this process and classify them into value-adding, business value-adding and non-value-adding.

Exercise 6.8 Consider the procure-to-pay process described in Exercise 1.7 (p. 29). Identify the steps in this process and classify them into value-adding, business value-adding and non-value-adding.

Exercise 6.9 Write an issue register for the pharmacy prescription fulfillment process described in Exercise 1.6 (p. 28). Analyze at least the following issues:

- Sometimes, a prescription cannot be filled because one or more drugs in the prescription are not in stock. The customer only learns this when they come to pick up their prescription.
- Oftentimes, when the customer arrives to pick up the drugs, they find out that they have to pay more than what they expected because their insurance policy does not cover the drugs in the prescription, or because the insurance company covers only a small percentage of the cost of the drugs.
- In a very small number of cases, the prescription cannot be filled because there is a potentially dangerous interaction between one of the drugs in the prescription and other drugs that the customer has been given in the past. The customer only finds out about this issue when they arrive to pick up the prescription.
- Some prescriptions can be filled multiple times. This is called a “refill”. Every prescription explicitly states whether a refill is allowed and if so how many refills are allowed. Sometimes, a prescription cannot be filled because the number of allowed refills has been reached. The pharmacist then tries to call the doctor who issued the prescription to check if the doctor would allow an additional refill. Sometimes, however, the doctor is unreachable or the doctor does not authorize the refill. The prescription is then left unfilled and the customer only finds it out when they arrive to pick-up the prescription.
- Oftentimes, especially during peak time, customers have to wait for more than 10 minutes to pick-up their prescription due to queues. Customers find this annoying because they find that having to come twice to the pharmacy (once for drop-off and once for pick-up) should allow the pharmacy ample time to avoid such queues at pick-up.
- Sometimes, the customer arrives at the scheduled time, but the prescription is not yet filled due to delays in the prescription fulfillment process.

When making assumptions to analyze these issues, you may choose to equate “oftentimes” with “20 % of prescriptions”, “sometimes” with “5 % of prescriptions” and “very small number of cases” with “1 % of prescriptions”. You may also assume that the entire chain of pharmacies consists of 200 pharmacies that serve 4 million prescriptions a year and that the annual revenue of the pharmacy chain attributable to prescriptions is € 200 million. You may also assume that every time a customer is dissatisfied when picking up a prescription, the probability that this customer will

not come back after this experience is 20 %. You may also assume that on average a customer requires five prescriptions per year.

Taking the issue register as a basis, apply Pareto Analysis to determine a subset of issues that should be addressed to reduce the customer churn due to dissatisfaction by at least 70 %. Customer churn is the number of customers who stop consuming services offered by a company at a given point in time. In this context, this means the number of customers who stop coming to the pharmacy due to a bad customer experience.

Exercise 6.10 Write an issue register for the procure-to-pay process described in Exercise 1.7 (p. 29).

6.7 Further Reading

Value-added analysis, cause–effect analysis, why–why analysis and Pareto analysis are just a handful of a much wider range of techniques used in the field of Six Sigma (cf. “Related Fields” box in Chap. 1). Conger [8] shows how these and other Six Sigma techniques can be applied for business process analysis. The list of analysis techniques encompassed by Six Sigma is very extensive. A comprehensive listing of Six Sigma techniques is maintained in the iSixSigma portal (<http://www.isixsigma.com/tools-templates/>). A given business process improvement project will generally only make use of a subset of these techniques. In this respect, Johannsen et al. [38] provide guidelines for selecting analysis techniques for a given BPM project.

Straker’s Quality Encyclopedia (see http://www.syque.com/improvement/a_encyclopedia.htm) provides a comprehensive compendium of concepts used in Six Sigma and other quality management disciplines. In particular, it provides definitions and illustrations of the 6M’s and the 4P’s used in cause–effect diagrams and other concepts related to root cause analysis. A related resource—also by Straker—is the Quality Toolbook, which summarizes a number of quality management techniques. Originally the Quality Toolbook was published as a hard-copy book [89], but it is nowadays also available freely in hyperlinked form at: http://www.syque.com/quality_tools/toolbook/toolbook.htm.

Why–why diagrams allow us to document sequences of cause–effect relations that link factors to a given issue. A related technique to capture cause–effect paths is the *causal factor chart* [77]. Causal factor charts are similar to why–why diagrams. A key difference is that in addition to capturing factors, causal factor charts also capture conditions surrounding the factors. For example, in addition to stating that “the clerk made a data entry mistake when creating the PO”, a causal factor chart might also include a condition corresponding to the question “in which part of the PO the clerk made a mistake?” These additional conditions allow analysts to more clearly define each factor.

The issue register has been proposed as a process analysis tool by Schwegmann and Laske [84]² who use the longer term “list of weaknesses and potential improvements” to refer to an issue register. Schwegmann and Laske argue that the issue register should be built up in parallel with the as-is model, meaning that the discovery of the as-is process and the documentation of issues should go hand in hand. The rationale is that during the workshops organized for the purpose of process discovery (cf. Chap. 5), workshop participants will often feel compelled to voice out issues related to different parts of the process. Therefore, process discovery is an occasion to start listing issues. Naturally, during process discovery, the documentation of issues is left incomplete because the focus is more on understanding the as-is process. Additional analysis after the process discovery phase is required in order to document the issues and their impact in detail.

Another framework commonly used for qualitative process analysis is the Theory of Constraints (TOC) [23]. TOC is especially useful when the goal is to trace weaknesses in the process to specific bottlenecks. In addition to providing a framework for process analysis, TOC also provides guidance to identify, plan and implement changes in order to address the identified bottlenecks. The application of TOC to business process analysis and redesign is discussed at length by Laguna and Marklund [43, Chap. 5] and by Rhee et al. [76].

Finally, a useful framework when it comes to analyzing individual tasks (or activities) in a business process—as opposed to the entire process—is provided by Harmon [31, Chap. 10].³ This so-called Task Analysis or Activity Analysis framework includes a comprehensive collection of questions and checklists that an analyst should answer and complete in order to identify opportunities to improve the performance of a given activity.

²The sub-categorization of the 6M’s given in Sect. 6.2.1 also comes from Schwegmann and Laske [84].

³An alternate reference describing this framework is [32].