Zero Shades of Gray—Reaching Zero Defects by Externalization of the Quality Philosophy into the Upstream Supply Chain

Johanna Ewald and Florian Schupp

1 Review of Literature

Based on the zero-defect philosophy, quality management and supply management are merging over the years toward supply quality management, which is focusing on evaluation, measuring and developing supplier quality performance.

Originating from the total quality movement, the zero-defect philosophy generated by Philip Crosby is the foundation of all interpretive quality activities, since "it is always cheaper to do the job right the first time" (Crosby 1979). Reaching this level requires a commitment to the zero-defect philosophy from all members of the supply chain (Weißbrich et al. 2008). In terms of Porter's corporate strategy (Porter 1999), supplier quality therefore has to be assigned to the functional strategy as a part of the supply strategy.

Deming and Juran were among the first ones to publish about quality in the purchasing process in the 1960s and 1970s. A deeper connection between quality management and supply management started in the late 1990, when it was recognized that a qualitatively high product can only be produced with a quality commitment of the whole supply chain (Ross 1998). This stretch of the total quality movement into the supply chain can be considered as a consequential step of completion (Ross 1998), while Levy (1998) contemplates supply chain quality management as a new organizational field. Today, the idea of supply chain quality evolves toward managing the supplier and improving its quality by evaluation, quality performance measurement and supplier development (Noshad and Awasthi 2014).

J. Ewald
Hochschule Furtwangen, Villingen-Schwenningen, Germany

F. Schupp (✉)
Jacobs University Bremen, Bremen, Germany
e-mail: F.Schupp@jacobs-university.de

F. Schupp and H. Wöhner (eds.), *The Nature of Purchasing*,
Management for Professionals, https://doi.org/10.1007/978-3-030-43502-8_3

Likewise, the evaluation of supplier performance has evolved over time, starting with Ishikawa's description of audits as an appropriate quality tool in the 1980s (Ishikawa 1985). Shrimali (2010) finds seven reoccurring steps for the supplier evaluation in literature: Identify critical commodities, identify critical suppliers, form a cross-functional team, meet with supplier's top management, identify key projects, create a target agreement and oversee status and strategies. Other quality-evaluating tools are capability analysis (Behrens 2008) and quality and reliability metrics (Fernandez 1995). Besides the mentioned quality tools, today's evaluation is also focusing on the cooperation between two companies. The cooperation level should be investigated, regarding the kind and the quality of the relationship. The supplier's stage of integration into the customer's processes (Pang and Tan 2017) and the relationship characteristics have a powerful impact on a company's delivery quality (Soares et al. 2017).

After evaluating the areas of failure, a performance measurement system should be implemented which provides information about the scope of failure (Supply Chain Council 2012). The creator of the zero-defect philosophy already found out that "people really like to be measured when the measurement is fair and open" (Crosby 1979). In terms of quality, a fair and open measurement system should reward those suppliers that deliver according to all service and product specifications (Sanchez-Rodriguez et al. 2005). Performance indicators for supplier quality can be used from the beginning of the product development process by measuring "success of new product introduction" down to the delivery of poor quality by "percentage of defective products received" or "defective parts per million" (Roberts 2013). The used measurement should emphasize on actions and improvement possibilities to help develop the supplier (Narasimhan and Kim 2002).

One main objective in supplier development is to improve the suppliers' overall quality (Hartley and Choi 1996). This can be supported by an internal quality management of the customer, which does not only impact the downstream quality directly but also significantly affect the upstream and downstream quality management in the supply chain (Zeng et al. 2012; Quang et al. 2016). Besides own quality improvement, long-term supplier–buyer relationships (Choi and Liker 2004), rewarding well-performing suppliers (Sanchez-Rodriguez et al. 2005) and quality trainings (Shokri et al. 2010) can support suppliers to improve. Besides the operational development, the supplier's management has to be involved in the process. It is not only part of the management responsibilities to establish a quality orientated mindset in a company (Feigenbaum 1993), but the practiced leadership style influences the quality performance of a company (Teonman and Ulengin 2017).

Literature is in most parts focusing on the supplier evaluation and development prior to the start of a serial production, launch of a product or ownership transition. The delivery of poor quality after the beginning of production in a business-to-business context has received less attention. Complaint management has often been investigated regarding consumer markets, but it is as well important in business-to-business markets since it can damage long-term relationships (Döscher 2014). Brock et al. found that important factors in handling complaints are

their effective processing and an adequate compensation of the potential loss (Brock et al. 2013). An emerging practice shows that an effective complaint processing can be ensured by a cross-company IT-Structure (Roberts 2013). Another tool, the 8D-Report, first introduced by the US Military in the norm "Corrective Action and Disposition System for Nonconforming Material," investigates the complaint out of eight different dimensions to ensure a holistic completion. It should prevent repetitive errors by identifying long-term improvement actions. With the completion signature from the customer, the responsibility is split between the customer and the supplier (Jung et al. 2011). Another revealing method is the cost tracking of poor quality delivered, which ensures a fair compensation of the failure costs incurred (Brock et al. 2013).

Only a few authors consider the connection between supplier quality development and complaint management in their publications. This relation is considered by using performance indicators like bad quality delivered to evaluate the supplier but not by developing the supplier based on occurring failures. This combination should be examined closer especially because product recalls in the automotive industry have increased during the past few years (Steinkamp and Reed 2016). This indicates that the approach of error prevention is not working properly. Some supplier rating systems are using the number of complaints among others as a quality performance indicator (Irlinger 2012). The advantage of using simply the absolute number of complaints as a base for supplier development needs a closer investigation. Besides performance measurement, other quality improvement measures should be defined. One possible approach is the analysis of root causes from previous complaints. Learning from the past failures shall make the definition of future improvement measures easier and more concrete. Additionally, it will open the possibility of defining the place and extent of supplier improvement actions.

Furthermore, when supplier quality development starts with internal quality management, then complaint management should also start with evaluating internal complaint processing by respective measuring. References about internal complaint management and how to measure this process are not closely observed by scholars, so far. The target is to find a measurement that provides information about the efficiency and effectiveness of the complaint process that improvements can be introduced. The following questions will be answered in the corresponding sub-chapter: Which possibilities exist to develop internal processes? Can supplier development methods be modified and implemented also at the customer?

2 Objective and Structure

The emphasized gaps in literature are the business-to-business complaint management, the connection between complaint management and supplier quality improvement and the evaluation and development of the customer's internal complaint process. Based on these gaps, this chapter deals with the supplier

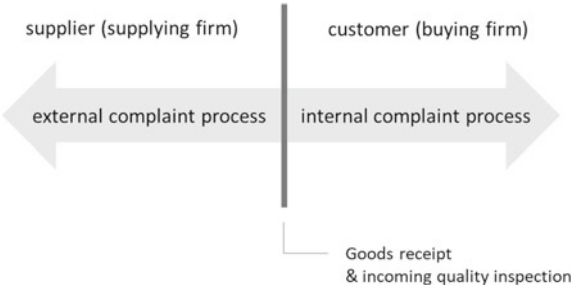

Fig. 1 Improving supplier quality by external and internal processes (authors' own figure)

complaint processing and connects it to supplier quality improvement. To illuminate the topic further, the chapter splits the complaint management into three different facets: supplier quality performance measurement, supplier quality improvement and the internal complaint process development. The measurement and analysis of poor quality of supplied parts or materials provide the basis for the conceptual conclusions in this chapter. The relative value of the measurement with absolute numbers will be answered, and a possible tracking procedure will be suggested. Based on the collected data, the implementation of protective, corrective and improvement actions will be discussed. While improving the supplying firm, opportunities to develop the customer's internal complaint processes are suggested. Therefore, an appropriate measurement system will be introduced, which builds the foundation for further improvements (Fig. 1).

3 Supplier Quality Performance Measurement

To measure supplier quality performance, the different performance indicators are compared with each other and among those the measurement of incidents or single claims is used as the basis for improvement. Using this performance indicator, a transparent tracking procedure is applied. In order to conceptually develop a holistic supplier quality management concept, supplier complaint data from a large, multinational supplier to the industrial and automobile industries is collected and analyzed.

3.1 Measuring Supplier Quality

The fact that a lot of "costs are arising due to poor quality" (Noshad and Awasthi 2015) confirms that many companies have not reached the zero-defect level yet. These costs have many different origins, for example, costs for line stops, return shipments or working time for complaint processing. They do not necessarily occur

for every defective part, rather for every opened complaint. The origin of each case differs and needs to be defined individually. To minimize costs and to reach the zero-defect level, an appropriate measurement system for poor quality delivered needs to be applied.

A common performance indicator for poor materials or components supplied in the automobile industry is the measurement of defective parts per million (Brunner and Wagner 2016). The measurement in parts per million shows the relation between the defective parts and the number of delivered parts. It does not show how many complaints were opened due to these defective parts. If a whole batch is defective, it results into one complaint. Meanwhile, several defective parts from several batches result into more than one complaint. Consequential, it is not possible to see the total number of complaints in this performance indicator. Furthermore, an improvement of this performance indicator can be achieved by delivering more parts and not by improving the absolute quality itself. However, zero-defective part per million indicates that the zero-defect strategy is fulfilled. In general, measuring a relation of indicators always faces the same problem. An immediate statement regarding the number of complaints and therefore the number of cases that need to be solved is not possible. A performance indicator, which makes the total number of occurring complaints visible, would be advantageous. The measurement of the absolute number of complaints is one possibility, which is already used for example in the automobile industry. This provides the opportunity to see the fulfillment of the zero-defect strategy and more important, the number of opened quality complaints. Another advantage of this performance indicator is the direct allocation of the complaint costs to each incident. Finally, ranking the different suppliers by the yearly number of complaints enhances the competition. The competition is harder, because a supplier can only improve his ranking by decreasing the number of yearly complaints, not by more deliveries. Concluding, the view of the authors is that measuring each complaint is the most advantageous performance indicator to decrease the number of complaints and their respective costs.

On the basis of a chosen performance indicator, the extent of the improvement needs to be defined. Therefore, a fixed target to be reached will be set. The overall target can be any number of yearly complaints; it should be challenging and reachable. Thus, each supplier shall be guided to reach zero defects with realistic steps.

Summarizing, the absolute number of complaints is the chosen performance indicator to measure the supplier's quality performance. This way of measuring fulfills the point of fairness, and it rewards suppliers that deliver according to all specifications. The target of the measurement system will be a fixed, challenging but reachable number of yearly complaints.

3.2 Strategic Supplier Quality Tracking and Improvement

Having chosen the performance indicator and the target, a clear tracking procedure needs to be developed. Transferring an ABC-Analysis into complaint management would mean that 20% of all suppliers are causing 80% of the complaints, 30% are causing 15% of the complaints and 50% are causing 5% of the complaints. Based on such an ABC-Analysis, evaluations mostly point toward the suppliers classified as A-Suppliers for rewarding or C-Suppliers for developing. The suppliers evaluated as neither good nor bad are often disregarded and therefore show a high risk of a quality decline. To avoid this, a fair complaint measurement system from the authors' point of view classifies into two groups with one group of suppliers causing complaints and another group of suppliers that have already reached zero defects. Suppliers causing 80% of the complaints are being defined as Flop-Suppliers, while suppliers causing the other 20% are called Non-Flop-Suppliers. Suppliers, which already fulfill zero defect, are called Zero-Defect-Suppliers and are representing the target for all other suppliers. The present work is establishing a link between complaint management and supplier quality management looking in an exemplary way into the supplier quality data of a large supplier to the automobile and industrial industries. This data is used to understand focus areas for supplier development from a quality perspective in a holistic way not limited to the actual data itself.

Concerning the introduced supplier classification method, the analyzed case data suggests that 66% of the suppliers can be classified as Zero-Defect-Suppliers and on the other hand 34% of the suppliers cause complaints. Out of these suppliers, 17% are causing 80% of the complaints and are classified as Flop-Suppliers, while 83% of these suppliers cause 20% of the complaints and are classified as Non-Flop-Suppliers (Fig. 2).

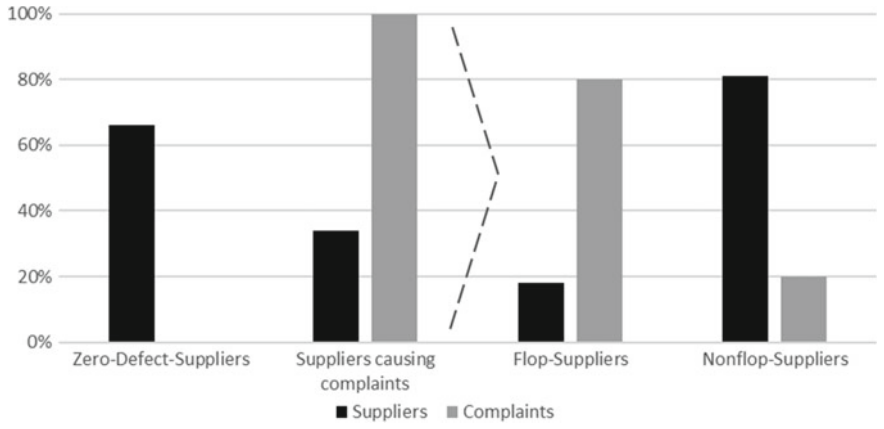

Fig. 2 Spread of suppliers causing complaints (authors' own figure)

In a first step in quality improvement, Flop-Suppliers will receive higher attention. It is recommendable to track their results individually to see the specific progress or regress. To see the progression immediately, the tracking on a monthly basis with all involved employees is necessary, as a holistic view on the supplier's performance can only be provided by an interdisciplinary team. Decision making or strategy changes based on the supplier's results will be discussed at this point as well. Furthermore, it is recommendable that the suppliers get an individual improvement target. This target is set in reference to the overall target and fulfills the same attributes as stated above. The special attention is not only for the measurement system, but also the improvement measures are defined individually. As illustrated in Fig. 3, the improvement process should be based on five basic steps. The first step of identifying the critical suppliers is already done. For these suppliers, expertise in the specific production processes will be applied (step 2) and meetings with the supplier's top management are taking place (step 3). It is important that the top management is involved in quality improvement, because it is their task to develop a quality program and a mindset for the company (Feigenbaum 1993). Further, the supplier's processes need to be improved on a technical level (step 4). Based on the results of improvement, target agreements have to be created (step 5). Since the technical capability of the supplier should gradually ameliorate, the last two steps of supplier quality improvement need to be overviewed regularly. In case of a significant negative drift of a supplier, another top management meeting should be reconsidered to align the company's quality standards.

In summary, the tracking procedure for supplier quality improvement is done by a classification of the suppliers into Flop-, Non-Flop- and Zero-Defect-Suppliers. This Flop-, Non-Flop-, Zero-Defect-Suppliers classification is a modification of the ABC-Analysis. Flop-Suppliers are tracked individually on a monthly basis to see their progress or regress. The supplier quality improvement is a process consisting of five steps in which the last two steps build a loop that should be reviewed on a regular time basis. In the following case, the historical complaint data of an automobile and industrial supplier has been analyzed. The occurring major technical problems of the suppliers will provide the basis of generalized quality improvement measures.

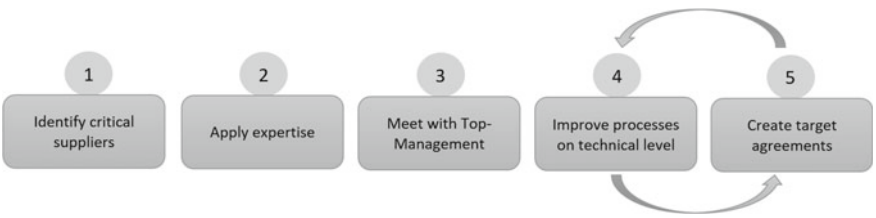

Fig. 3 Five steps of supplier quality improvement (authors' own figure)

3.3 Database for Quality Improvement Measures

An occurring error pattern is only a sign for the *existence* of a problem. Eliminating this error pattern does not necessarily solve a problem sustainably, analogous to medicine. Medicating the symptom does not mean the disease should not occur again. The same disease could probably come to the surface again or potentially even through another symptom. Therefore, the root cause needs to be found and to be eliminated to sustainably remove one problem.

To build a database for the elimination of root causes, the complaint data from the analyzed company was collected. All complaints of Flop- and Non-Flop-Suppliers delivering to different plants of the customer were taken into consideration. The root causes of the respective complaints were detected by an Ishikawa diagram (Ishikawa 1976) and a 5-Why Analysis, first introduced by Sakichi Toyoda in the Toyota Motor Corporation (Ohno 1988), as part of the 8D-Report. Resulting over a period of nine months, 333 complaints were investigated.

In a first step, occurring root causes were counted according to the seven influence factors (refer to Fig. 4) used in the Ishikawa diagrams, also called seven M's: Management, Man (human), Material, Measurement, Machine, Mother Nature and Method.

A first analysis of the data shows that 30% of the investigated complaints cannot be reproduced due to an incompletion of the 8D-Report. However, human, method and machine are the root cause of 195 complaints, which represent 59% of all complaints. The other 11% are separated into the four missing influence factors. Because of the gap between the three main influence factors and the other ones, only the ones occurring the most will be further investigated to introduce improvement measures. Resulting from the incomplete 8D-Report, improvement measures for the development of the internal complaint process will be followed.

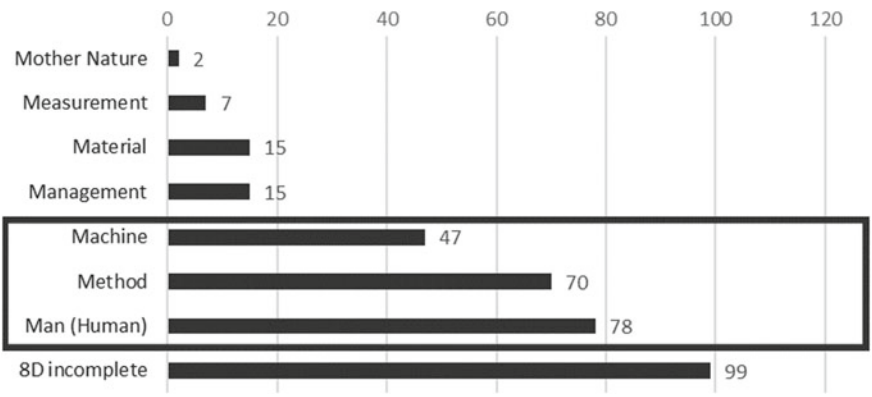

Fig. 4 Root causes classified by the number of occurrence and the different influence factors (authors' own figure)

In the following paragraphs, the different root causes for the three main influence factors are introduced. These influence factors do not occur more frequently in one of the observed plants or in a specific month. Therefore, the analysis will be carried out without a differentiation by plants. Following the Pareto analysis, the problems with the highest occurrence need to be eliminated first.

The method as a cause of complaints looks at all supplier processes. This does not only involve the production process but also logistical processes such as packaging, storage or internal transportation. Generally, the frequency of occurring methodological errors refers to the supplier's lack on control over their processes. To improve the suppliers' processes, customers install supportive functions inhouse, which should manage the suppliers' quality as a starting point of improvement (Noshad and Awasthi 2015). The results of the presented case further show the need for a function that manages the supplier quality after the start of series production. The case shows that additional development methods and actions need to be defined and realized between supplier and customer. The basis for further improvement is built by the information about the different causes as shown in Fig. 5. The data analysis shows that nine different root causes occur related to the Ishikawa influence factor *Method*. Out of these, 70% of the complaints root causes are wrongly implemented production and logistic processes and production line setup. Because the occurrence of these root causes is predominant, actions to reduce the number of complaints in these three areas will be illuminated in the chapter "Supplier quality improvement measures." Since the other six root causes occur more seldomly, detailed improvement measures should be investigated and implemented case by case (Fig. 5).

The Ishikawa factor *Man* describes complaints, which are based on human mistakes. The three most frequently occurring root causes are work instruction ignored, slip in control and setting parts delivered, contributing to 50% of

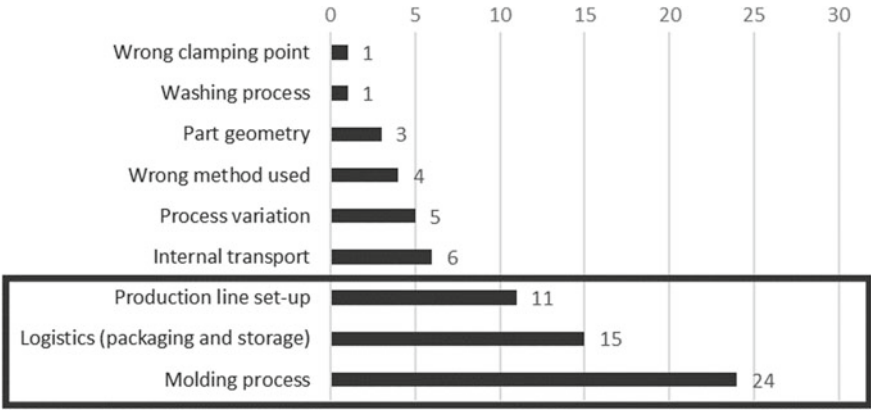

Fig. 5 Different root causes of the influence factor method classified by the number of occurrence (authors' own figure)

human-influenced complaints. The root-cause slip in control describes the process of visual control, e.g., at the end of the production line. Such control is used, when a technology is not robust enough to fulfill the zero-defect strategy. Possible measures for these human-based mistakes will be introduced in the chapter "Supplier quality improvement measures." The other 50% of human-influenced factors are caused by seven different root causes (Fig. 6).

The complaints based on a *Machine* influence show a smaller deviation in the different root causes. Almost 80% of the complaints originate from either a defective machine on which the production continued or from tool wear. This root cause refers to tool usage after the maximum production output was reached. To reduce the number of machine-based complaints, measures for these two root causes should be implemented (Fig. 7).

Concluding, the analysis of 333 complaints shows that 23% of the complaints are based on the influence factor *man*, 21% on the influence factor *method* and 15% on the influence factor *machine*. It also shows that a big amount of complaints was

Fig. 6 Different root causes of the influence factor man (human) classified by the number of occurrence (authors' own figure)

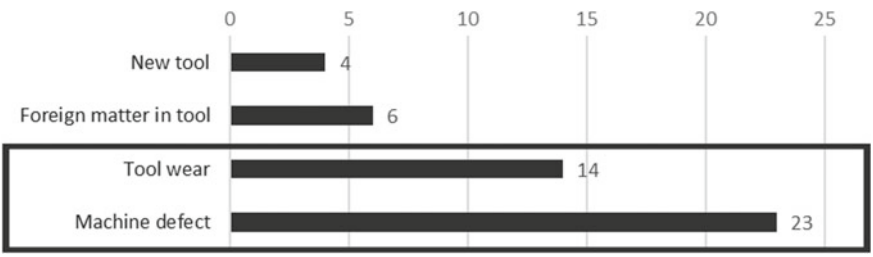

Fig. 7 Different root causes of the influence factor machine classified by the number of occurrence (authors' own figure)

not able to be reproduced due to a lack in the 8D-Report processing. Further, the data confirms that the complaints originate from several different root causes and working in cross-functional teams to resolve the claims can be advantageous. The raised data is setting the basis for the following improvement measures.

4 Supplier Quality Improvement Measures

To ensure that good quality will be delivered in future, protective and improvement actions need to be consequently implemented. At first it needs to be clarified, where these actions should be applied. In the presented case, the quality inspection of incoming goods rarely projects the complaints and therefore the production line is rather identifying bad parts, while producing the own product. This sole way of working shall be avoided. The suppliers commit to deliver parts according to the aligned specification. It is not the customer's duty to ensure the supplied parts quality level. Furthermore, a clear statement that poor quality is not acceptable should be made toward the supplying firm. With the target to put pressure on the supplier and to minimize the default risk at the customer's plant, all corrective actions need to be implemented at the supplier's plant.

These improvement measures can be divided into four main areas (refer to Fig. 8). They are immediate protective actions, limited protective measures, permanent corrective measures and sustainable improvement measures. Only sustainable improvement measures can improve the supplier's processes from a process robustness point of view. Not all technologies can reach zero defects from a technical point of view (Töpfer 2007), sustainable improvement measures are supported by the implementation of permanent corrective actions. Furthermore, protective measures, which ensure a quick coverage of parts delivered in bad quality, will be explained.

An immediate protective action is used whenever the supplier has delivered poor quality. The main focus is to guarantee that no further defective parts will be received from the same defective batch. Therefore, the stock at the supplier's plant and the goods in transit will be sorted 100% by the supplier. This measure is meant

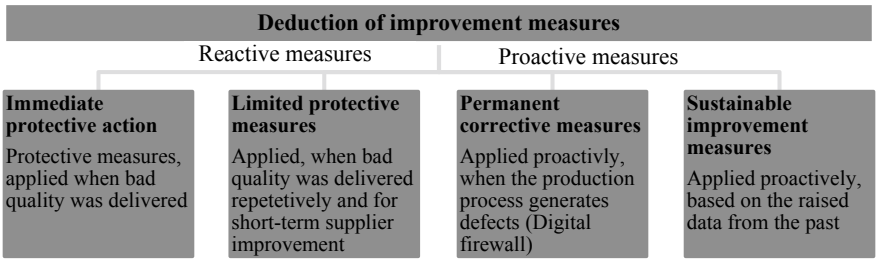

Fig. 8 Different levels of supplier quality improvement measures (authors' own figure)

to avoid further defect parts, which disturb the production process. Still, this is only a short-term protective measure, and for actual quality improvement, additional measures need to be found.

If suppliers deliver several errors on the same product or show repetitive errors, the limited protective measure of controlled shipments will apply. Controlled shipments are commonly used as quality tools in several industries. Controlled shipment measures can be differentiated into three levels of inspection. It targets to ensure the suppliers delivered quality based on a 100% visual control. At the same time, the supplier should evaluate his occurring faults and learn from them for the future. The goal is an improvement of the internal supplier production process regarding the occurring faults.

The Controlled Shipment Level concept consists of three basic steps:

1. 100% inspection by the supplier
2. 100% control by an external service provider
3. 100% control by an external service provider and new business hold.

The supplier moves one escalation level up whenever another defective part of the same part number is delivered to the customer. Important is that this tool is not made to ban suppliers, but to develop them immediately and for the future. This tool is designed for a short-term improvement and learning process, and it is used reactively to enhance the pressure toward the supplier. The last step of this tool is called "new business hold." This final step puts pressure on the supplier to increase his quality level. Certainly, the Controlled Shipment Level is often utilized with Flop-Suppliers, because they mostly show repetitive errors. Still, when Non-Flop-Suppliers have problems with one particular part number or part family, such a tool can prevent the customer from too many defective parts in their production. Accordingly, to develop supplier quality on a long-term horizon, permanent corrective or sustainable improvement measures need to be implemented.

Permanent corrective measures are applied especially in technologies, which cannot fulfill the zero-defect philosophy from a production process stability point of view. The main idea behind this action is to ensure that good quality is delivered to the customer, although the production process can generate defects. In order to deliver according to the zero-defect strategy, a permanent 100% control needs to be implemented. Traditionally, employees would carry out a visual control at the end of the production line. As the presented case data shows, 15% of the human mistakes are slip in these end-of-line controls. This can be explained by the average error detection for automotive components of about 90–98% (See 2012). To prevent the slip in the visual control and to avoid these complaints, the suppliers can, for example, implement automatic camera control systems, which can be called digital firewalls. Digital firewalls can be used as 100% end-of-line control and are more effective than the human eye. The camera control systems are investments, which will probably redeem due to the fact that no compensation costs for complaints occur. This is still not the final target, because bad quality is produced and the intended way for the supplying and customer is to totally avoid the production of bad quality.

For a better cost efficiency, sustainable improvement measures need to be implemented. The goal of these measures is to improve the processes and not to separate good parts from bad parts. These measures are defined by data raised from the past (refer to Figs. 5, 6 and 7) and should be implemented to reduce complaints on a technical level. The data revealed that the influence factors method, human and machine are most frequently leading to complaints.

4.1 Influence Factor Method

In the following paragraphs, possible improvement measures for the earlier identified most often occurring root causes of the influence factor method, production processes, logistics and production line setup are described.

Production process:

Plastic injection molding and metal casting processes are combined in this root cause for the present dataset. In general, the target is to optimize molding and casting processes by implementing sensor techniques. These sensor techniques should monitor the real-time data from the practical molding and casting processes and compare them with the theoretically and required set data. The permanent target-performance comparison should provide information about deviations in the process and delimit parameter-based failures in the production process. The real-time monitoring of molding and casting processes can lead to an enhanced quality performance with a saving potential of 3–5% from the manufacturing cost at the casting company and potential quality cost savings at the customer (Larsen 2018).

Logistics (Storage and Packaging):

Logistics problems that result into quality complaints are either originating from a too long storage time or from insufficient packaging specifications. A main influence factor on the storage time is the used type of storage and the used inventory managing method. The first-in first-out inventory managing method is predestined to be carried out in a wrong manner, when the storage is organized in blocks or bulks. The faulty execution of the inventory managing methods, or the chosen storage organization, could possibly lead to longer storage times, which many materials cannot withstand. The storage problems can occur after the production at the supplier plant and after the arrival at the buying plant. To avoid these problems, a detailed view of the first-in first-out procedure is necessary. A better reconciliation between the supplying and customer could lead to a shorter storage time. In general, the target of this measure is to reduce the storage time.

To avoid problems based on wrong packaging, a look into the details is necessary. Before every new ordered product, packaging specification needs to be aligned. To identify the right packaging specification, the transportation method or

storage should be analyzed as well. An example from the regarded data includes a supplier that delivered a product continental and overseas. The packaging specification for this product was the same for the two different locations. As a result, the supplier had big rust issues with the product delivered overseas, because this packaging was not sufficient. The example shows that there is a need to deeply investigate every case and then align packaging standards and if necessary, define two different storage and packaging specifications for different ship to locations.

Production line setup:

Avoiding production-line-based problems, one effective tool could be a reverse Failure Mode and Effects Analysis (FMEA). Such reverse process FMEA is a continuous improvement tool used to analyze new risks occurring during the real-life serial production of a product, while the original FMEA tries to predict potential failures in the future. Therefore, an interdisciplinary team inspects the production line and tries to identify all possible failures in a manufacturing or assembly process. Actions to correct the possible failures are defined and are transferred to the other production lines (Parrott et al. 2011). This process should be repeated several times. Processing the reverse FMEA in a short interval in the beginning is recommendable. The tool is especially useful to identify not functional sensors and equipment or similar, equipment which lost its functionality due to rework of the production line.

4.2 Influence Factor Man (Human)

In a next step, improvement measures for the influence factor human will be introduced. In general, one-third of the complaints in the analyzed dataset are caused by humans. Assuming that these failures are not intentional, the lessons from these are that the operators' knowledge needs to be enhanced toward a good quality production. In general, it seems like there is no sensitivity for quality communicated and forwarded from the management to the operators. Besides workshops by the own supplier quality department, an employee of the customer can perform trainings at the supplier plant. The employee of the customer has a higher authority to address this topic. Further, the trainings should be held repetitively, in order to actually change the mindset of the operators. Building a better knowledge and mindset should help operators to work according to work instructions.

Nevertheless, zero defects cannot be ensured by eliminating human failures through trainings. Technical improvements, which guarantee that inattention does not lead to a failure, should be established. Therefore, the implementation of Poka-Yoke systems at the supplier's plant is recommendable for every critical production step. The lean manufacturing tool Poka-Yoke is designed to exclude errors caused by operators and to correct them on a long-term time horizon, through

an optimization of the workspace. Quality employees of the customer can support the introduction of the system and help with the implementation if necessary.

Work instruction ignored

Supportive to the explained tool, the focal firm of the present case suggested another quality tool, which is known as linewalk or Gemba Walk. This tool has the character of an audit carried out by the supplier himself. It consists of different audit like questions about the operator, setter and the production line itself. The suppliers' quality department employee walks by the production line once a week, asks the audit questions and identifies poor working sections. Immediately after finishing the linewalk, the employee gives feedback to the operators and setters. The tool reveals human-based problems like the missing qualification of employees or an unclear definition of work instructions. Based on this feedback, improvement actions are suggested. Other employees and managers can perform this tool on a lower frequency and give their feedback.

Setting parts delivered

Before a machine can be released for the serial production, a first batch of parts is produced which may not fulfill the aligned specifications. Of course, this batch is not supposed to be delivered to the customer. Normally, the operators are sensitive to these parts and know that this batch should not be delivered. Besides this sensitivity, which never is a final exclusion of a defect, other actions need to be implemented, so that complaints due to this root cause do not occur. Therefore, an automatization of the removal process of parts out of specification produced after setting a machine should be considered as an additional measure. On the basis of a standardized setup process, which includes the determination of a specific number of defective parts produced after the setup, an automatic removal of these parts should be implemented. The automatic removal should also be applied after each and every planned or unplanned interruption of production.

4.3 Influence Factor Machine

The root-cause machine defect and tool wear can be eliminated by implementing sensor techniques already described for molding and casting processes. These techniques shall identify parameters, which indicate that the machine has a defect or the tools' maximum output is exceeded. By automating this process, the human influence on this root cause as well as the root cause itself can be eliminated.

In summary, by implementing measures to improve the method, machine and human-based complaints, about 50% of complaints could be avoided in the presented case. Regarding the number of missing 8D-Reports, this number could even be higher if the same root causes occur repetitively. Of course, every customer has to identify the causes of complaints in the past individually and apply their expertise

as suggested in the second supplier quality improvement step. The shown measures give an example how supplier quality can be improved by digging deep into the details of complaints. According to the analyzed data, the 8D-Report processing can be improved as well. The next chapter will indicate possible ways to improve here.

5 Developing Internal Complaint Processes

The quality of internal processes at the customer is setting the base for further improvements. Identifying weaknesses of the own complaint processes will reveal the areas of improvement possibilities. Looking at the respective procedures of complaint processes, each customer will identify its own weaknesses in the process. As shown in the chapter "Database for quality improvement measures" in the observed firm, one weakness was the 8D-Report processing. Almost 30% of the reports of Non-Flop-Suppliers are not filled out properly or the complaints were processed without an 8D-Report. Looking into both, the complaints from Flop-Suppliers and Non-Flop-Suppliers, about 25% of the 8D-Reports, are not processed properly. The second step is to identify the causes for the incompletion of the 8D-Reports. It was observed that the processing time of the reports took very long. This means the efficiency of the document is not given. A second cause is a not satisfying content of the reports; therefore, the effectiveness needs to be improved. Performance measurement is defined as the efficiency and effectiveness of action (Neely et al. 1995). This leads toward defining a measurement system, which identifies the actual efficiency *and* effectiveness of the 8D-Report.

5.1 Efficiency of the 8D-Report

First, the completion time of the 8D-Reports will be further investigated. The first three disciplines of the 8D-Report should be closed after 24 h (Jung et al. 2011). The exact processing time for all disciplines is depending on the requirement of the customer. Different companies show that their required average processing time until D5 should take between 8 and 12 business days (Verband der Automobilindustrie e.V. 2017). Processing the required documents in time is not only the responsibility of the supplier. The supplier quality department employee of the customer should track and remind the supplier to turn the document in on time. Therefore, part of the responsibility is on the customer. To guarantee that the customer has a fast processing, the average processing time can be measured. To improve the processing time, further actions can be implemented either directly at the customer's plant or at the supplier. As a supportive tool, an integrated ERP-System application for complaint management can be used at the buying and the supplying firm. Such systems provide automatic reminders and help to keep the overview. As a result, the average D5 completion time should be under 12 working days over all proceeded 8D-Reports.

5.2 Effectiveness of the 8D-Report

Besides decreasing the processing time, the equally important part of the 8D-Report is the quality of its content. Especially the content from dimension four, root-cause analysis, to dimension seven, implementation of corrective actions, is important. To determine where quality problems occur, a content measurement should be implemented. "People will only tell you the troubles that others cause for them. They will not reveal what they make happen themselves." (Crosby 1979). Therefore, a direct measurement is not recommendable. This suggest implementing an indirect performance indicator will be better to measure the effectiveness of an 8D-Report. The target of the tool is to eliminate errors after the first time they occurred. Accordingly, an 8D-Report is called effective, when a complaint does not occur a second time. Repetitive errors can only occur, when a wrong root cause was identified, or the permanent corrective actions were not sufficient. Measuring the number of repeated complaints is a possibility to measure the effectiveness of the 8D-Report. Repetitive errors do not only count, when a fault appears a second time on the same part but also on a similar part from the same supplier. It should be the supplier's interest to implement the corrective actions translationally. Accordingly, the content and therefore the effectiveness of the 8D-Report will be measured indirectly by the number of repeated complaints.

With this measurement, suppliers with the most repetitive errors can be identified.

Finally, as a part of the measurement procedure, the correlation between the two performance indicators will be observed. Therefore, it needs to be determined if the processing time has an influence on the effectiveness of the 8D-Report. A worst-case scenario shows a short processing time with a negative correlation with effectiveness. In this case, the effectiveness of the 8D-Report should be given a greater value upon the processing time. The best case is a positive influence of the processing time toward the effectiveness. Therefore, a high effectiveness and a short processing time show a positive correlation. This correlation needs to be investigated. The target is a high effectiveness and efficiency of the 8D-Report. To reach it, the earlier introduced improvement tools can be implemented.

In summary, the 8D measurement enhances the quality of the 8D-Report content. The average processing time will improve, and consequently, the buying company will be more reactive toward supplier development because the knowledge about the complaint is provided faster and with better content.

6 Summary

This chapter discusses the importance of connecting quality improvement and complaint management in supply management. In fact, quality issues cannot always be avoided and also suddenly occur *when* well-though-about serial production processes have been started. Each quality incident provides a chance to start with

the supplier quality improvement and respective optimization possibilities. The performance evaluation indicator of choice for supplier quality is the absolute number of complaints.

Three groups of suppliers can be differentiated after being ranked by the absolute number of complaints. Flop-Suppliers are causing 80% of the complaints and are the main focus of quality improvement. Non-Flop-Suppliers cause 20% of the complaints, and so-called Zero-Defect-Suppliers have already reached the zero-defect level. Identifying the critical suppliers is the first main step in supplier quality improvement. For these focus suppliers, expertise should be applied to understand the specific production processes that have led to the failure and consequently to the complaints. As only the top management can fundamentally develop a quality mindset, meetings with their involvement and the respective customers' counterparts have to take place. Afterward, the supplier production process shall be developed on a technical level. The analysis of the present case data shows that there are three main improvement areas: wrongly implemented production, logistics or packaging processes, human mistakes and defective machines. Improving these processes by implementing sustainable improvement measures or permanent corrective measures and creating target agreements is the final step in supplier quality improvement. The latter two steps are ongoing and have to be repeated on a regular basis until zero defect is reached.

In addition to the external improvement, the supplier quality evaluation processes inside the customer should be developed. One perception from the analyzed data is the high amount of complaints which cannot be reproduced due to a lack in the 8D processing. This lack can be explained by the missing efficiency and effectiveness of the document. To improve the complaint process, performance indicators for the two attributes are introduced. For the efficiency, the average processing time is measured, and to evaluate the effectiveness, the number of repetitive complaints can be used. Based on these indicators, improvement measures can be derived.

References

Behrens, R. (2008). In *Boeing Supplier Strategy and Lean, 93rd Annual Conference on Supply Chain Management, St. Louis, MO*.

Brock, C., Blut, M., Evanschitzky, H., & Kenning, P. (2013). Satisfaction with complaint handling: A replication study on its determinants in a business-to-business context. *International Journal of Research in Marketing, 30,* 319–322.

Brunner, F., & Wagner, K. (2016). *Qualitätsmanagement: Leitfaden für Studium und Praxis* (6th ed.). München, Germany.

Crosby, P. (1979). *Quality is free: The art of making quality certain* (1st ed.). New York, NY.

Choi, T., & Liker, J. (2004, December). Building deep supplier relationships. *Harvard Business Review*.

Döscher, K. (2014). *Recovery Management in business-to-business markets: Conceptual dimensions, relational consequences and financial contributions*.

Feigenbaum, A. (1993). Creating the quality mindset among senior managers. *National Productivity Review, 12*(3), 313+.

Fernandez, R. (1995). *Total quality in purchasing & supplier management* (1st ed.). Miami, Fl: St. Lucie Press.

Hartley, J., & Choi, T. (1996). Supplier development: Customers as a catalyst of process change. *Business Horizon, 39,* 37–44.

Irlinger, W. (2012). *Kausalmodelle zur Lieferantenbewertung* (1st ed.). Passau.

Ishikawa, K. (1976). *Guide to quality control, Asian productivity organization* (2nd ed.). Tokyo.

Ishikawa, K. (1985). *What is total quality control? The Japanese way*. London: Pentice Hall.

Jung, B., Schweißer, S., & Wappis, J. (2011). *2011, 8D und 7 step—Systematisch Probleme lösen*. München, Deutschland: E-book.

Larsen, P. (2018). Digitalisierung im Einkauf from Schupp F., Woehner, H. (pp. 199–108). Springer Fachmedien Wiesbaden. 978-3-658-16909-1.

Levy, P. (1998). Total quality management in the supply chain. In *Handbook of total quality management* (pp. 275–303).

Narasimhan, R., & Kim, A. (2002). Effect of supply chain integration on the relationship between diversification and performance: Evidence from Japanese and Korean firms. *Journal of Operations Management, 20,* 303–323.

Neely, A., Gregory, M., & Platts, K. (1995). Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management, 15*(4), 80–116.

Noshad, K., & Awasthi, A. (2015). Supplier quality development: A review of literature and industrial practices. *International Journal of Production Research, 53*(2), 466–487.

Ohno, T. (1988). Toyota production system: Beyond large-scale production (1st ed.). Portland: Productivity Press.

Pang, J., & Tan, K. (2017). Supply chain quality and pricing decisions under multi-manufacturer competition. *Industrial Management & Data Systems, 118*(1), 164–187.

Parrott, K., Mattes, P., & Stahl, D. (2011). Applying advanced FMEA methods to vehicle fire cause determinations. In *ASME 2011 International Mechanical Engineering Congress and Exposition Volume 9*, Denver, Colorado, USA.

Porter, M. (1999). Competitive strategy: Techniques for analyzing industries and competitors. Free Press, ISBN: 0684841487.

Quang, H., Sampaio, P., Carvalho, M., Fernandes, A., Thi, D., & Vilhenac, E. (2016). An extensive structural model of supply chain quality management and firm performance. *International Journal of Quality & Reliability Management, 33*(4), 444–464.

Roberts, M. (2013 September 12). Top 5 supplier quality management strategies. *Quality Digest Magazine*.

Ross, D. (1998). Competing through supply chain management: Creating market-winning strategies through supply chain partnerships (1st ed.). New York, NY.

Sanchez-Rodriguez, C., Hemsworth, D., & Martinez-Lorente, A. (2005). Quality management practices in the purchasing function: An empirical study. *International Journal of Operations & Production Management, 24*(7), 666–687.

See, J. (2012). Visual inspection: A review of the literature. Sandia National Laboratories, Albuquerque, New Mexico.

Shokri, A., Nabhani, F., & Hodgson, S. (2010). Supplier development practice: Arising the problems of upstream delivery for a food distribution SME in the UK. *Robotics and Computer Integrated Manufacturing, 26*(6), 639–646.

Shrimali, L. (2010). Analysis of success factors for supplier development (Master thesis). San Diego State University.

Soares, A., Soltani, E., & Liao, Y. (2017). The influence of supply chain quality management practices on quality performance: An empirical investigation. *Supply Chain Management: An International Journal, 22*(2), 122–144.

Steinkamp, N., & Reed, J. (2016). Automotive warranty and recall report 2015. Stout Risius, Ross Global Financial Advisory Service.

Supply Chain Council. (2012). SCOR Quick Reference Guide, Item No. 726770, Texas.

Teonman, S., & Ulengin, F. (2017). The impact of management leadership on quality performance throughout a supply chain: An empirical study. *Journal of Total Quality Management & Business Excellence, 29*(11–12).

Töpfer, A. (2007). Six sigma: Konzeption und Erfolgsbeispiele für praktizierte Null-Fehler-Qualität (4th ed.). Berlin, Germany.

Verband der Automobilindustrie e.V. (2017). Qualitätsmanagement-Methoden Assessments Leitfaden (1st ed). Berlin, Germany.

Weißbrich, A., Fuchsbauer, B., Heinrichs, H., & Plegnier, H. (2008). Qualitätsmanagement in der gesamten Wertschöpfungskette: Grundlagen des gemeinsamen Erfolgs, Automobiltechnische Zeitschrift, Ausgabe 01/2008.

Zeng, J., Phan, C.A., & Matsui, Y. (2012). Supply chain quality management practices and performance: An empirical study. Published online 13 January 2013. New York: Springer Science + Business Media.

Johanna Ewald is a project purchaser for hybrid systems at Schaeffler Automotive, an international automotive tier-1 supplier. She graduated as MSc in International Management at Furtwangen University, Germany. Her research interests are performance measurement of supplier quality and practical implication of supplier quality improvement. Since joining Schaeffler in 2019, she has been e-motor competent purchaser for multiple projects.

Prof. Dr.-Ing. Florian Schupp works as Senior Vice President Purchasing & Supplier Management Automotive OEM at the Schaeffler Group, Germany. He completed his Ph.D. at the Technical University of Berlin in the field of strategy development in purchasing and logistics and has 21 years of purchasing experience in the companies Schaeffler, Continental, Siemens and Sony. He integrates practical purchasing and supply management work with academic research together with the University of Lappeenranta, Finland; the University of Catania, Italy; the Université Savoie Mont Blanc, Chambéry, France; the Technical University Berlin, Germany; and the Jacobs University Bremen, Germany. He teaches purchasing and supply management in Bremen and Berlin. Main research interests are purchasing strategy, behavioral aspects in purchasing, purchasing in nature and supplier innovation. Schupp is member of the Advisory Board of BLG Logistics, Bremen, Germany and the Advisory Board of Xtronic, Böblingen, Germany. Since 2019, he is Adjunct Professor for Logistics at the Jacobs University Bremen, Germany.