Chapter 2
Elements of JIT

The aim of this book is to identify the key elements that ensure the success of JIT, the benefits that companies obtain, and the causes of its slow implementation or abandonment. In addition, this book integrates these elements in causal models and associates those JIT elements identified with the benefits that companies obtain and the causes of a slow progress in its implementation. These models could allow managers and administrators to identify the elements that are essential for the success of JIT and those that cause great delay of the expected benefits. Thus, to achieve this, all crucial elements of JIT philosophy are first defined, along with the causes of a slow JIT implementation and the benefits. Once these elements were identified and discussed, the structural models were proposed.

This chapter mostly relies on Kumar et al. (2004), Singh and Garg (2011), Kumar (2010) to discuss the elements that ensure a successful JIT implementation. Authors identified a total of 34 elements, which were divided into three groups for the purpose of this research:

1. Elements associated with human resources
2. Elements associated with the production process
3. Elements associated with the product

2.1 JIT Elements Associated with Human Resources

If JIT is considered a philosophy of production, some of its elements must be associated with human resources or factors, since any philosophy is inherent of humans. The 12 elements associated to these human resources and proposed by Kumar et al. (2004), Singh and Garg (2011), Kumar (2010) were categorized and listed in Table 2.1. The first column stands for the names of every element while the second column includes the names of authors who have referred to every element. Finally, the third column contains the number of authors in total who referred to each element.

Note that in Table 2.1 elements are arranged in a descending order according to the number of references reported for every one. The first five elements have a total

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Table 2.1 JIT elements associated with human resources

Name of item	Authors	Quote
Flexible workforce	(Baker et al. 1994; Hall 1983; Garg et al. 1996b; Hong et al. 1992; Yasin et al. 2003; Prodipto 1999; Pyane 1993; Saxena and Sohay 1999)	8
Zero deviation in production programs	(Garg et al. 1994, 1996a; Singh 1989; Ebrahimpour and Schonberger 1984; Garg 1997; Garg and Deshmukh 1999b; Voss and Robinson 1987; Yasin et al. 2003)	8
Multifunctional workers	(Bonito 1990; Delbridge 1995; Garg 1997; Garg and Deshmukh 1999b; Garg et al. 1994; Sewell and Wilkinson 1992; Singhvi 1992; Yasin et al. 2003)	8
Workers motivation	(Bonito 1990; Delbridge 1995; Fiedler et al. 1993; Garg et al. 1994, 1996a; Sewell and Wilkinson 1992; Vrat et al. 1993; Kumar et al. 2001)	8
Short delivery times	(Singh 1989; Chong and Rundus 2000; Ebrahimpour and Schonberger 1984; Garg and Deshmukh 1999a; Singhvi 1992; Vrat et al. 1993; Voss 1986; Kumar and Garg 2000)	8
Error prevention	(Chong and Rundus 2000; Garg 1997; Garg and Deshmukh 1999b; Hall 1983; Vrat et al. 1993; Kumar and Garg 2000)	6
Long-term contracts	(Kumar and Garg 2000; Vrat et al. 1993; Garg and Deshmukh 1999b; Garg et al. 1996a; Garg 1997)	5
Self-correction of errors	(Voss 1986; Garg and Deshmukh 1999b; Garg et al. 1994; Garg 1997; Ebrahimpour and Schonberger 1984)	5
Employee empowerment in QC	(Singh 1989; Delbridge 1995; Garg and Deshmukh 1999a; Hall 1983; Priestman 1985)	5
Supplier quality certification	(Garg et al. 1996a; Garg 1997; Garg and Deshmukh 1999b; Kumar et al. 2001)	5
Evaluation and selection of suppliers	(Garg et al. 1996a; Garg 1997; Garg and Deshmukh 1999b)	3
Effective communication	(Gilbert 1990; Yasin et al. 2003)	2

of eight references, there is only one element with six references, four elements with five, one element with three, and finally, one element with two references is reported.

A definition of each element is provided in order to identify why they are part of this group.

1. *Flexible workforce*: This element has several dimensions, but the most important concerns availability of operators and the opportunity for them to hold more than one position, which is discussed in the third element related to multifunctional workers (Asendorf and Schultz-Wild 1984). As for flexible hours, its importance can be understood by analyzing the following scenario: Let us suppose that a certain company receives an urgent request or production order at 2:30 p.m., and the departure time of all workers is at 3:00 p.m. Due to

the urgency of this order, workers will be required to work overtime; otherwise, the production order would probably be delivered late to the customer.
Flexible workforce is created through education and training, along with the establishment of clear policies for its implementation, since there are often Constitutional or Federal rights in labor laws that are clear in terms of the payment of overtime work, the holidays granted, and more. Authors Kohler and Schultz-Wild (1985) discussed the issues and policies that may be found when companies seek to implement a flexible workforce. Similarly, Toikka (1987) analyzed the procedures that companies should follow in order to develop their workforce in an environment of visible manufacturing.

2. *Zero deviation in the production program*: JIT programs are important to monitor the work plans generated, since deviations could cause delays in other production orders. To avoid any deviation in production programs, some managers stated that there must be some certainty in demand. However, at the same time they can complain that many customers continuously ask for urgent orders. Thus, in order to meet the requests, companies require making changes in their production plans already set. Fortunately, the task-scheduling problem has been widely studied from an academic point of view, since deviations in production plans are very common. Several models can be found nowadays based on optimization aimed at minimizing deviation. For instance, Crama (1997) refers to a model of combinatorial optimization for task scheduling, while Greene and Sadowski (1986), Sawik (2007) mentioned a model based on integer programming. Similarly, models in Li et al. (2015) are multi-target, since the proper programming of activities does not only seek to minimize the cost, but also to make appropriate use of available resources.
3. *Multifunctional workers*: This element refers to the availability of workers or people responsible for the production process to perform various activities in the production line. Hence, if any member were missing or stopped attending, any other worker could replace him/her in the position or job. That means that the production line would not be affected and would always have continuous flow thanks to the training and flexibility of workers. This could ensure a just-in-time production system without delay. Some authors recommend drawing upon the rotation of employees around the different positions so they can perform and train in different skills. This way, an employer can make adjustments with greater fluidity whenever he/she requires (Corominas et al. 2006) and without the obstacles due to attendance problems or unfortunate accidents. Although this element is ranked third in this category, authors such as Martínez-Jurado et al. (2014) consider it the most important element for the success of lean manufacturing tools, including the JIT methodology or philosophy.
4. *Workers motivation*: Many authors discuss this element and it is also one of the most important associated with human resources. Although it is difficult to actually measure the motivation of employees or operators online, JIT considers that this element is crucial, since an unmotivated employee will not seek the

achievement of the goals of the company. Therefore, companies should seek by all means to motivate their employees and make them feel part of the company with the purpose of creating a corporate identity. Thus, companies must seek that their employees feel proud of their employment, the product that they manufacture, and the organization to which they belong. In other words, employers want their employees to put their shirt on. Only motivated employees will seek to achieve the objectives of the company. Several works in the literature address the role of motivation in the industry and many of them are recent. For instance, Diefendorff and Seaton (2015) analyzed in detail of the importance of motivation in the workplace. Their analysis focused primarily on operational levels, while Barron and Hulleman (2015) rather emphasized on the analysis of financial costs for a company when it obtained an adequate program of work motivation. Finally, authors Anderman and Gray (2015) discussed the relationship between motivation and the educational levels of operators.

5. *Short delivery times*: In this element, managers must seek short delivery rates in order to have constant flow of deliveries in the production system. Some managers mentioned that companies held a much closer relationship with customers who asked for short delivery times than with those customers whose deliveries took longer periods of time. In these cases, managers stated that sometimes companies did not know the customers. Thus, short delivery times with customers strengthen relations between the two parties in which people maintain contact.
6. *Error prevention*: JIT philosophy is based on human resources, but as part of our human nature, many mistakes can occur both in the production line and in the administration. Hence, it is important that companies have a system of error prevention to avoid problems within the production system, since mistakes can delay a production order. This often happens because defective pieces must be reprocessed when possible, since sometimes an entire piece is wasted and must be thus rebuilt from its beginning. This implies a delay in just-in-time delivery. Error prevention is also aimed at preventing fatalities, such as accidents of the operators that may result in the loss of a limb. Thus, researchers have also discussed its importance. For instance, Liu et al. (2009) proposed an economic analysis of the mistakes made by the employee in a manufacturing environment. Similarly, Ruckart and Burgess (2007) proposed an analysis of the cost of errors in the mining and manufacturing sectors.

   Clear examples of the efforts made by many companies to avoid mistakes are training simulators, such as those offered to pilots in many airlines. In these simulators, workers are introduced to specific situations to measure their responsiveness and quality of decisions. The study of Di Pasquale et al. (2015) discussed a simulator to analyze human errors, a concept that many works on manufacturing recently name reliability (Baraldi et al. 2015; Mkrtchyan et al. 2015).
7. *Long-term contracts*: These types of contracts generally happen when demand has little uncertainty with the customer and when the company is familiarized

with the client and vice versa. Thus, the client knows the processing capacity of the producer and the producer consequently knows the needs of the customer. This means that with long-term contracts and a reduction of uncertainty from both parties, deliveries of production orders tend to be on time.

Long-term contracts with suppliers have been extensively studied, but as noted in Cannon et al. (2010), these relationships are not always possible, especially because of factors related to the culture where companies operate. In these cases, it is recommended that buyers frequently perform a series of audits to their suppliers in order to maintain their relationship (Chen and Jeter 2008). Also, other authors go beyond seeing suppliers as sellers of raw materials, they rather consider suppliers as partners in the production system (Chicksand). However, these long-term relationships that consolidate that much, could pose a number of problems. However, Costello (2013) proposed a series of strategies to resolve such conflicts that may arise, and Frascatore and Mahmoodi (2008) defined a number of possibilities related to the sanctions that could be applied when any of the parties fails in the purchasing and selling process. Similarly, Xu et al. (2015) addressed batch sizes that could be ordered due to unforeseen changes in the demand.

8. *Self-correction*: This concerns the ability of workers to correct their mistakes without the need of supervisors. It is related to the degree of authority that supervisors grant to their employees, since if there were no authority, there would not be responsibility either. However, to ensure self-correction of defects, employees or workers in the production line must have high education, since they must be able to identify the error and provide a solution. Thus, if a certain employee does not have the authority to self-correct defects, the supervisor will likely detect it and decide how to correct it. Then, the process to solve that problem would certainly require much time, since the supervisor would assign its solution to another employee, and this represents high administrative costs. Granting authority to an employee is commonly known as empowerment and this concept involves many cultural and psychological aspects, since many people do not wish to take responsibility for their actions (Chu 2003; Paul et al. 2000) in Western companies and which are very natural. As Cheung et al. (2012) stated, the administration should be based on giving authority and responsibility to employees. Recently, Tong et al. (2015) expressed that strong leadership in work teams of the manufacturing process is required in order to delegate responsibilities, since these are an immediate reflection or mirror of supervisors or senior managers.
9. *Authority for quality control to workers*: This element is closely related to the previous one, since it means that every worker has the control of quality over every processes carried out. This means that workers can take appropriate actions to remedy quality defects that they can detect, which implies an ability of self-correcting defects. However, a worker can be able to correct the defects he found either in his/her process or in previous ones, but if he/she does not

have the authority to correct them, it is likely that their education and training will not be enough.

Empowerment of workers must be related to the responsibilities they hold in the production process. Workers must be trained people so they can be granted with authority but also responsibility. Authority given to workers over quality control is essential in JIT because product quality largely depends on the skills and abilities of employees. Thus, a product or order can be delivered on time if employees are able to determine, identify, and correct errors without waiting for a supervisor to detect them. This type of authority conferred to workers in relation to the quality of products has called for the attention of many researchers and academics. In de Macedo-Soares and Lucas (1995), authors carried out a study of this phenomenon in which they compared Brazilian and American companies by identifying cultural and educational aspects. Four years later, Howard and Foster (1999) discussed the influence of human factors and their perspective on the final quality of a product. More recently, Tong et al. (2015) performed an analysis about leadership and delegation of authority and responsibility to employees. They emphasized on confidence when performing manufacturing activities. They also concluded that employees were to some extent responsible for the safety performance of activities, and that companies must provide proper methods to perform them.

10. *Supplier quality certification*: A supply chain begins with raw materials from suppliers; hence, the production process starts with them, which will be later transformed into finished products. It is well known that if waste enters the production process, waste will come out as a final product. Therefore, raw material suppliers most count on quality certifications. This suggests that they can be an integral part of the production system, not just as a supplier but also as a partner. Let us suppose that a company requests an order to a supplier and the supplier delivers the wrong part or component, or a correct but defective component. Obtaining the appropriate piece would mean, from an administrative point of view, to return the material to be replaced, which would imply waste of time and costs. Hence, a quality accreditation or certification is also a guarantee of the administrative capacities of suppliers. The vendor certification process and its impact on the quality of the final product have been studied by Park et al. (1996), who argued that the best way to hold a good relationship with a supplier is having few of them, although, in times of uncertainty, having a single supplier for a particular part or component could probably pose a number of problems of shortage (Larson and Kulchitsky 1998). With recent advances in certification, many providers already count on ISO regulations and its guidelines (Terlaak and King 2006) and some of them include environmental or ecological aspects (Ullah et al. 2014; Nguyen and Hens 2015).
11. *Seller rating*: Every company should conduct an evaluation of its suppliers in order to know if they meet the expected requirements, which are often properly set by their quality systems and certifications (Kohlbeck 2011). Low valuations of suppliers indicate that they do not meet the expected metrics for the

company. Therefore, these suppliers can be easily identified by companies, which could then look for and identify alternative suppliers. It is worth mentioning that all suppliers have the right and must know the metrics under which they were evaluated, so companies have the obligation to make these public. Some other companies offer a monthly report to their suppliers with statistics of the relationships they maintain. The report also informs of delays in deliveries, incomplete deliveries, and percentage of defective products, among others. Suppliers with high valuations metrics ensure that products are delivered on time since the supplier system is guaranteed.

12. *Effective communication*: Now that market globalization forces companies to have suppliers from around the world, effective communication to the outside must be effective. However, communication must also be successful within the company between the different hierarchical levels. It must be wide and ensure the flow of appropriate information to avoid mistakes and misunderstandings. If there is no communication between departments in the production line, they will surely have issues with information and material flow, and this can heavily compromise just-in-time deliveries. In Japanese companies, the following process in a production line is always considered as a customer; this perspective ensures that all departments establish open communication. This way they are guaranteeing the satisfaction of their clients. From a social point of view, there are many studies that have analyzed the phenomenon of communication in companies; some of them also discussed the protocols to be followed to ensure it (Huang et al. 2009). Undoubtedly, information and communication technologies today play an important role, since information is rapidly shared between suppliers and buyers. As a result, production systems are often linked and exchange this information in real time (Aliu and Halili 2013), minimizing supply chains globally. As authors Jiang and Liu (2015) stated, who conducted a study in the coal sector.

2.2 JIT Elements Associated with Production Processes

JIT is a philosophy that largely depends on human resources. However, once raw materials arrive in warehouse, they enter the production process, and this process also plays an essential role in just-in-time deliveries of finished products and the elimination of waste.

Table 2.2 of this section discusses those JIT elements associated with the production process. The first column contains the name of the elements, while the second stands for the name of authors who identified each element and considered it important to illustrate JIT. Finally, the third column includes the total number of authors who referred to that element. The elements were arranged in descending order according to the total number of authors who mentioned them.

Table 2.2 JIT elements associated with production processes

JIT elements—process	Authors	Total
Kanban system	(Singh 1989; Hall 1983; Saxena and Sohay 1999; Pyane 1993; Prodipto 1999; Pan and Liao 1989; Muralidharan et al. 2001; Yasin et al. 2003; Hong et al. 1992; Kim and Ha 2003; Kumar and Garg 2000; Voss and Robinson 1987; Vrat et al. 1993; Padukone and Subba 1993; Garg and Deshmukh 1999b; Garg et al. 1996a; Garg 1997)	17
Preparation time reduction (SMED)	(Singh 1989; Hall 1983; Saxena and Sohay 1999; Pyane 1993; Prodipto 1999; Vrat et al. 1993; Hong et al. 1992; Baker et al. 1994; Kumar and Garg 2000; Singhvi 1992; Padukone and Subba 1993; Daesung and Seung-Lae 1997)	17
Small lot sizes	(Dutton 1990; Ebrahimpour and Schonberger 1984; Hall 1983; Singhvi 1992; Vrat et al. 1993; Baker et al. 1994; Bose and Rao 1988; Golhar and Stamm 1991; Hong et al. 1992; Pan and Liao 1989; Prodipto 1999; Garg et al. 1996a; Garg and Deshmukh 1999b; Daesung and Seung-Lae 1997)	14
Cellular manufacturing	(Singh 1989; Hall 1983; Saxena and Sohay 1999; Prodipto 1999; Vrat et al. 1993; Kumar and Garg 2000; Yasin et al. 2001; Voss and Robinson 1987; Garg and Deshmukh 1999b; Garg et al. 1996b; Garg 1997)	12
Safety stock	(Singh 1989; Hall 1983; Kumar and Garg 2000; Vuppalapati et al. 1995; Vrat et al. 1993; Padukone and Subba 1993; Dutton 1990; Chong and Rundus 2000; Ebrahimpour and Schonberger 1984; Garg 1997; Garg and Deshmukh 1999b; Garg et al. 1996a)	12
Improved plant layout	(Hall 1983; Pyane 1993; Prodipto 1999; Baker et al. 1994; Padukone and Subba 1993; Yasin et al. 2001; Voss and Robinson 1987; Garg and Deshmukh 1999b; Garg et al. 1996b; Garg 1997)	10
Just-in-time purchases	(Hall 1983; Saxena and Sohay 1999; Pyane 1993; Prodipto 1999; Vrat et al. 1993; Mohan and Singh 1995; Yasin et al. 2001; Goyal and Deshmukh 1992)	8
Process control	(Singh 1989; Prodipto 1999; Hong et al. 1992; Ha and Kim 1997; Kumar et al. 2001; Priestman 1985; Padukone and Subba 1993; Garg and Deshmukh 1999b)	8
Standardized containers	(Hall 1983; Prodipto 1999; Kumar and Garg 2000; Ebrahimpour and Schonberger 1984; Yasin et al. 2001; Voss and Robinson 1987; Garg and Deshmukh 1999b)	7
Group technology	(Singh 1989; Kumar and Garg 2000; Vuppalapati et al. 1995; Padukone and Subba 1993; Chong and Rundus 2000; Voss and Robinson 1987; Garg and Deshmukh 1999b)	7
Process flexibility	(Hall 1983; Vrat et al. 1993; Hong et al. 1992; Daesung and Seung-Lae 1997; Baker et al. 1994)	5
Reduction of work in process	(Ebrahimpour and Schonberger 1984; Vrat et al. 1993; Kumar and Garg 2000; Prodipto 1999; Garg and Deshmukh 1999b)	5

(continued)

Table 2.2 (continued)

JIT elements—process	Authors	Total
Continuous improvement	(Hall 1983; Prodipto 1999; Vrat et al. 1993; Garg et al. 1996b)	4
Specialized factories	(Saxena and Sohay 1999; Pyane 1993; Yasin et al. 2001)	3
Kaizen	(Ebrahimpour and Schonberger 1984; Garg 1997; Voss and Robinson 1987)	3
Scheduling below installed capacity	(Yasin et al. 2001; Garg et al. 1996b)	2
Use of robots	(Conzalez and Suarez-Gonzalez 2001; Garg et al. 1996b)	2
Pull system	(Baker et al. 1994; Conzalez and Suarez-Gonzalez 2001)	2

The following paragraphs briefly discuss each element in order to explain their importance in this group:

1. *Kanban system*: We cannot speak of a Kanban system without defining it. Kanban is an information system traditionally used to harmoniously control and indicate what must be produced in a production system. In other words, it controls and indicates the amount and timing required to carry out an activity (Panayiotou and Cassandras 1999). A Kanban is usually represented by a simple card indicating the characteristics of the product-to-be. This information card can be used inside and outside the company. It can be used in the company as the production system itself, and outside as a method to exchange information between companies (Chan 2001). A typical example could be in an automotive assembly line. A card could be placed in the car at the beginning of the production system, when only the chassis or the main support of the car is placed. This card would indicate the characteristics of the car-to-be, such as the type, its color, the type of built-in speakers, whether it would have electric windows and buttons, or whether it would include fog lights. This way, operators in the assembly line could always know the kind of components to integrate into the chassis without a supervisor indicating. It would ensure continuous production flows, which would favor just-in-time deliveries and waste disposal of assemblies of unwanted components.
   Kanban as a system or tool applied in a production line might be the most important tool to ensure the flow of materials; which is why it was ranked as the first element (17 references identified in total). One could also consider that Kanban is a very efficient tool to ensure proper delivery of information in the production line and, thus, avoid mistakes. For a more thorough review of the application of Kanban in the industry, readers are welcome to consult (Lage Junior and Godinho Filho 2010).
2. *Preparation Time Reduction (SMED)*: Maintaining the continuous flow of materials through the production system is not an easy task, since machines and equipment used to transform the materials frequently break down or must be

adjusted when companies make changes in their product (Ferradás and Salonitis 2013). This is why Henry Ford said that he could paint a car in any color that customers asked, as long as it was black. Henry Ford knew that making changes to the paint line in a process costs money, and as a result, his product could become more expensive. However, it must be kept in mind that a batch size for a client is only one product; this ensures that the product is fully customized.

The SMED program was proposed to minimize time required to put the machinery and equipment to point (Almomani et al. 2013). This technique emerged in the automotive sector and focused mainly on changing tools from lathes, milling machines, and material grinding equipment. Thus, in a production system, the programs to reduce setup times for machines and equipment are based both on the analysis of unnecessary movements by operators and machines and the design of these machines. It is important to highlight that in order to meet short preparation times, people in the company should be highly trained and skilled to identify all unnecessary movements.

3. *Small lot sizes*: As it was previously mentioned, large batch is desirable for suppliers, since they will not need to make changes in their production line. This will reduce production costs and, thus, favor a greater competitiveness. However, from the point of view of customer companies, small batch sizes or low volume production are rather preferable since they allow these organizations to own much more customized products with very specific characteristics. Thus, there must be a balance between the needs of the customer firm and those from the suppliers, although in an environment of JIT, it is not an easy task (Khan and Sarker 2002; Kim and Ha 2003). Moreover, small batch sizes represent less expenses of inventory maintenance to manufacturing companies, who will always look for that. However, having little inventory implies a mature and trustful relationship with the supplier, which does not always happen. If the supplier does deliver raw materials on time and the producer does not have sufficient inventory, the production process might stop due to a lack of raw materials (Lovell 2003). Therefore, a company that has begun applying just-in-time manufacturing must have certified suppliers with high valuations and which are fully integrated into the production system and have become reliable. This will save inventory costs for companies, as it did for Toyota, Dell, and many others that have reported success in implementing JIT in their production systems.
4. *Cellular manufacturing*: Companies usually have a representative product and always seek to be leaders in it, which means that they have many other products in their production line (Erenay et al. 2015). In order to achieve high levels of expertise, some firms generate a mini-factory within the large factory where they bring together all machinery and equipment to develop a certain product or process. As it was already mentioned, the gain is that the company becomes specialist in that product, suggesting high reliability of its production process and high training of its human resources (Deep and Singh 2015). With these

resources, the company can always face rapid changes in the product and avoid human mistakes and mistakes in the process, which assures just-in-time deliveries. Many approaches have been proposed for the integration of manufacturing cells, which are often based on binary optimization that always aims at minimizing costs and delivery times. Some examples can be found in Aalaei and Davoudpour (2015), Brown (2014), Mahdavi et al. (2012).

5. *Safety stock*: The uncertainty in demand forces companies to have a safety stock inventory. The most suitable scenario would be one where producers know with absolute certainty what will happen with the demand; they could order the raw materials only when needed without experiencing storage costs. Companies do not want to experience marginal costs due to a lack of product in inventory. Thus, a security stock may be a necessary evil until the emergence of models that integrate all variables to predict demand. A safety stock can be defined as the amount of raw material or finished product that the company has in arms to meet any unforeseen event (Sarkar and Tripathy 2002). For instance, if a company receives a production order for any material or product and one component is missing since it is out of both the traditional and the safety stock inventories, it is likely that the product will suffer from late deliveries even with a just-in-time philosophy. This is why having a safety stock is considered as one of the most important elements of JIT associated with production processes. Other typical examples of safety stocks are food stocks (Lee et al. 2014) and blood banks from the government. They exist in order to be used when required.
6. *Improved plant layout*: There is one scenario that I usually give my students to demonstrate the importance of material handling. The diagram of a traditional process includes operations, inspections, transport, storage, and some delays. If the process removed all transport, delays, and stores under the premise that they do not add value to the product, the process diagram would consist only of those activities associated with operations and inspections. This is most likely to be a paradox, or fictitious, since the storage of raw material and safety stocks are needed, as it was mentioned above. However, engineers can focus on minimizing these values, especially the ones related to the transport of raw materials and finished products. This is achieved with an appropriate distribution of the process.

   The impact plant layout in companies and the improvements in efficiency ratios in a just-in-time program have been extensively studied. For example, while Yasin et al. (1997) introduced an analysis of the efficiency of JIT and found that one of its reasons was precisely distribution. Similarly, White and Prybutok (2001) analyzed the good practices of the JIT philosophy and concluded that distribution of the production process was perhaps the most important. Similarly, Inman et al. (2011), Alcaraz et al. (2014), authors described structural equation models which demonstrated that a good distribution of the production process was the source of agility, since it avoided unnecessary movements of raw materials and finished products that added no value whatsoever.

7. *Just-in-time purchases*: It is traditionally thought that JIT philosophy is only applied in the production system; however JIT starts from the process of procurement of raw materials and components. Thus, as mentioned above, implementing JIT involves the commitment from the purchasing department early in the production process and the distribution department at the end of it. JIT Purchasing ensures that companies meet the needs of their production systems, since delays in raw materials could cause delays all throughout the production process. However, this element requires certified and reliable suppliers that are part of the production system, which would imply great level of dependence between the buyer and seller (Handfield 1993) and could bring a number of advantages for the manufacturing company (Giunipero and O'Neal 1988).
   The obstacles that may arise when reaching a purchasing program with JIT tend to be quickly resolved. Furthermore, the program proposes many benefits for business (Dong et al. 2001), although two questions will always be under discussion: how far the relationship between buyer and seller can go, and to what extent the seller should be involved in the decision-making process of the buyer (David and Eben-Chaime 2003).
8. *Process control*: The supply chain of a company could be divided into three stages: the supply of raw materials, the production process, and the distribution of the finished product. How would it be if any of these stages were not under control? What would happen if there was a lack of control in the production process? Could JIT be applied in an uncontrolled production process?
   If any of the stages of the supply chain lacked of control, companies would be unable to know the kind of materials in stock, the products that are currently in the production line, or those that are being delivered to customers. This is a situation that managers would certainly wish to avoid. Similarly, if the production process lacked of control companies may not know which product or orders have initiated the production process, their stage in it, or when they would be finished, which may be catastrophic. Thus, it would be impossible to implement JIT philosophy without any control on the production process, which demonstrates that control plays a key role in the success of the JIT program. In fact, Benton and Shin (1998) suggested that companies needed a proper planning process, since it was recently shown that the relationship between process control and performance indices of the supply chain was statistically significant and noticeably high (Alcaraz et al. 2014).
   In Huq (1999) the author mentions a series of procedures that seek to approach JIT philosophy from a production process based on projects. This may be interesting to many, since JIT philosophy is generally applied to mass production systems.
9. *Standardized containers*: In Chap. 1 of this book mentioned, lean manufacturing (LM) is based, among others, on a series of tools that are essential for its

success. One of these tools is the standardization of processes, which begins by standardizing parts, one of which are the containers in which raw materials are placed in order to be assembled or turned into finished products to distribute.

10. *Group technology*: If a company has been or must be a specialist in a given operation or activity, its equipment and machinery are likely divided into different technology groups. This means that similar operations are performed in the same place, which requires the formation of product families. This allows companies to take advantage of the similarities of machinery and processes for greater fluidity in the material. This consequently improves the efficiency of just-in-time deliveries. It has been found that group technology for production offers several advantages such as agility (Inman et al. 2011), higher levels of product quality and processing, and specialized care provided to machinery and equipment (Cua et al. 2001). However, these changes in production organization also require a series of organizational modifications, which are often neglected in businesses but should never be forgotten in order to ensure on-time deliveries (Yasin et al. 2003).
11. *Process flexibility*: Flexibility can be defined as the ability of a company to make quick adjustments to the products (Gupta et al. 1992). It must not be confused with agility, which is the capacity of quick response to fluctuations in demand. A flexible process is where machinery and equipment can perform different activities and are not specialized in one. For instance, if a very specialized machine in a company broke down, the production manager could be in a serious problem, since the company may not count on another machine to replace the damaged one and perform its activities. If instead of being specialized, the two were multifunctional pieces of equipment, one could surely replace the other and adapt to its new activities through rapid reprogramming. Indeed, the specialization process definitely provides many advantages, but it also implies drawbacks, such as the one described above. The advantages of the specialized equipment are high quality and speed in its processes; nonetheless, it may be challenging to adapt a specialized machine so it can carry out a different activity. This becomes a particular disadvantage since purchasing industrial machinery is usually expensive. Thus, as Moattar Husseini et al. (2006), Inman et al. (2011) stated, there must exist a balance between flexibility in the machinery and equipment and the cost that companies are willing to experience for the agility that it requires.
12. *Reduction of work in process*: Having piles of raw material in the process must be an issue for production managers, since they are not being processed at the moment and are just stored anywhere. Besides, they are not receiving any added value whatsoever. This is why process inventory should be reduced to a minimum, although it is usually a challenging task because many operations and activities throughout the production process have different execution times and, therefore, grouping activities and balancing the production line is a permanent issue (Houghton and Portougal 1997). A reduced work in process means that the production line is balanced and, thus, the flow of materials throughout it is smooth and continuous. This suggests that a considerable

amount of waste in the production process has been eliminated and companies have a greater opportunity to meet deliveries on time.

13. *Continuous improvement*: Kaizen or continuous improvement has been widely researched in production systems and represents a philosophy by itself. The main idea in continuous improvement is that there is not such thing as a perfect process. That is, the process can be improved. Companies that have applied this philosophy have gained great economic benefits. Indeed, accepting that a whole process can be improved makes organizations think that it can always be upgraded, simplified or, expedited. This would lead to faster production cycles and, therefore, timely delivery of processes and products to customers.
    It is considered that the implementation of Kaizen largely depends on operators, since they can suggest most of the changes and improvements because they are the most acquainted of the machinery and the equipment they operate as well as the process for which they are responsible. Thus, implementing a system of suggestions from them would mean listening to the voice of those who run the operations. Similarly, it is often stated that in quality systems it is important to listen to the voice of the customer; however, in this case, it is imperative to listen to the voice of operators.
    The implementation of Kaizen in Western companies is not an easy task, since some working conditions are different from those of Eastern companies, which is why Western business might face major challenges for its implementation (Machuca 2002). These challenges have become the topic of discussion for several pieces of research that seek to identify the critical success factors of Kaizen. For instance, Farris et al. (2009) reported a list of factors found in manufacturing systems in the United States, while structural equations in Mexico have reported a series of relationships that ensure the success of this technique (García et al. 2013, 2014). It shall not be forgotten that people are responsible for the improvement of any process, and that people and processes together produce quality products. Therefore, improvements always come from human resources.
14. *Specialized factories*: Another tool to ensure on-time deliveries is to rely on specialized factories. In fact, a minor change to a new product could lead to big changes in equipment, since these tend to be less flexible. Thus, from the viewpoint of JIT, a specialized factory is more suitable due to the advantages that it provides, which are: the process is usually quickly executed, the personnel who operates it is highly skilled and trained in quality processes, preventive maintenance of equipment is possible, and the process has high fluidity of materials since operations are properly balanced. However, it is always recommended to find a balance in the flexibility expected from these specialized factories, since they require a very standardized product that would suffer few changes in its design.
15. *Kaizen*: Although number 13 refers to continuous improvement and this one discusses Kaizen, it must be emphasized that both concepts stand for the same element. While Eastern companies commonly employ the term Kaizen,

Western industries are much more familiar with the expression "continuous improvement."

The list of elements associated with production processes provided was based on the results found by Kumar (2010), Kumar and Garg (2000), Kumar et al. (2001, 2004), who actually discussed and analyzed the two concepts separately. As a personal conclusion regarding both concepts, it would be suitable, as Recht and Wilderom (1998) stated, to focus on analyzing the cultures of the companies that implement JIT and Kaizen. Thus, it is vital for the success of both JIT and organizations that they implement a system of opinions through which employees make suggestions to improve the production process. A production process that constantly improves is certainly a highly efficient process in all its aspects, starting with its workforce, who makes these suggestions and gives opinions.

16. *Scheduling below installed capacity*: Although not frequently mentioned, scheduling production below the installed capacity guarantees orders delivered on time. However, when companies schedule above their installed production capacity it usually results in problems, such as delayed deliveries, poor-quality products and, consequently, loss of customer trust.

    Many businesses accept orders above its production capacity so they do not lose their opportunity to make business. However, it is also true that these companies can outsource to other companies to perform some of their production. These techniques are traditionally called outsourcing. However, the company that accepts the production order is responsible for the quality and on-time delivery of products of the company that hired it to manufacture part of the amount committed. Some typical examples of outsourcing are found in the automotive sector (Collins et al. 1997). It has also been observed that sometimes this process of outsourcing has lead to issues of strong reliance on external companies (Yilmaz and Bedük 2014), which is why control systems must be extremely rigorous. Others authors, however, have wondered whether a service provider is actually required when outsourcing activities are performed (Dabhilkar et al. 2009).

17. *Use of robots*: It is traditionally believed that robots do not make mistakes but people who fabricate, design, and program them do. However, robots are machines that can be disqualified and lose their ability and accuracy over time and with their uses in production systems. As for their roles inside JIT production systems, robots perform tasks that are difficult, require high precision, or are dangerous, guarantee that the production process will not stop in case of accidents or human errors. Moreover, in a program of preventive and corrective maintenance, robots continue working without the constraints of a possible strike for salary increase. Thus, the flow of materials through the production process is kept continuous and steady, which favors just-in-time deliveries. However, it must also be mentioned that robots are highly specialized equipment that require highly trained personnel, not only to operate and maintain them, but also to program them or reprogram them when they are taken from

one line of production to another, or when changes are made to the design specifications and activities of the robot.

18. *Pull system*: A pull system can be defined as a system that only produces what the client requests. That means that a production order is generated solely when the company already relies on the customer and a sale contract. It does not occur to store products or involve workers in the production process, because if it did, the product could remain long time in the warehouses of the company with its own storage costs. Inventories along the production process or at the end of it as finished products do not exist in pull systems, since the product is manufactured and delivered to the customer at the moment. Readers who wish to further learn about this production system may consult (Ohno 2011), which discusses control levels in pull systems with JIT.

2.3 JIT Elements Associated with the Product

Table 2.3 lists the elements for the success of JIT that are associated with the product. As in prior tables, the first column includes the name of the element, while the second stands for the authors who have referred to that element. The third column corresponds to the total number of authors who have quoted each element.

All elements in this category relate to quality, which is one characteristic of products. Some readers may think that these elements really belong to the category of production process and not product, which may be correct since quality is generated in the process. However, since all of the elements stood for a product characteristic (quality), they were included in this category.

1. *Quality Circles*: Quality circles were a huge phenomenon in the decade of 1980. Their purpose was to know the voice of the employees or workers who were, and still are, the most familiarized with the production system. A quality circle is integrated by a group of coworkers seeking to solve problems in production lines. QCs have nowadays become rare, since the popularity of Kaizen has replaced them, although they essentially remain the same. Participating in quality circles implies a great commitment to the company, as it sought and seeks to provide solutions to everyday problems. Quality circles were more present in Japan, although the West quickly adopted them due to their operational benefits (Blair and Ramsing 1983). One of the first nations to integrate quality circles in the West was apparently the United Kingdom, (Hayward and Dale 1984; Frazer and Dale 1986); yet, the rush for its adoption caused many mistakes in their application and most of the time the approach was abandoned (Pascarella 1985).

   Some authors even expressed that there were many cultural factors associated with quality circles, since they required collaborative work from a group of employees, which is often difficult to achieve (Manson and Dale 1989).

Table 2.3 JIT elements associated with the product

JIT elements—product	Authors	Total
Quality circles	(Saxena and Sohay 1999; Maass et al. 1989; Singhvi 1992; Vrat et al. 1993; Priestman 1985; Padukone and Subba 1993; Nandi 1988; Bonito 1990; Garg et al. 1994; Chong and Rundus 2000; Garg 1997; Singh 1989; Yasin et al. 2001; Garg and Deshmukh 1999b)	14
Total quality control	(Hall 1983; Saxena and Sohay 1999; Vrat et al. 1993; Padukone and Subba 1993; Dutton 1990; Ebrahimpour and Schonberger 1984; Garg 1997; Flynn et al. 1995; Yasin et al. 2001)	9
Statistical quality control	(Kumar et al. 2001; Priestman 1985; Padukone and Subba 1993; Dutton 1990; Singh 1989; Voss and Robinson 1987; Garg and Deshmukh 1999b; Kumar and Garg 2000)	8
Quality development programs	(Hall 1983; Macbeth et al. 1988; Baker et al. 1994; Chong and Rundus 2000; Yasin et al. 2001; Garg 1997; Voss and Robinson 1987)	7
Continuous quality improvement	(Hall 1983; Singhvi 1992; Chong and Rundus 2000; Ebrahimpour and Schonberger 1984; Garg and Deshmukh 1999b; Garg 1997)	6
Zero defects	(Prodipto 1999; Kumar and Garg 2000; Ebrahimpour and Schonberger 1984; Garg and Deshmukh 1999b; Garg 1997)	5
Quality-oriented training	(Singhvi 1992; Vrat et al. 1993; Garg et al. 1994, 1996b; Singh 1989)	5
High visibility of QC	(Hall 1983; Kumar et al. 2001; Priestman 1985; Dutton 1990; Ebrahimpour and Schonberger 1984)	5
Long-term QC commitment	(Hall 1983; Kumar et al. 2001; Priestman 1985; Dutton 1990)	4
Regulate quality and reliability of audits	(Kumar et al. 2001; Nandi 1988; Garg and Deshmukh 1999b)	3
Quality culture	(Kumar et al. 2001; Singhvi 1992; Flynn et al. 1995)	3
100 % quality inspection	(Kumar et al. 2001; Kumar and Garg 2000; Singh 1989)	3
Simplifying the process of total quality	(Kumar et al. 2001; Bonito 1990; Ebrahimpour and Schonberger 1984)	3

However, it is a consensus that quality circles really improve production processes and bring quality benefits (Brennan 1990; Rosenfeld et al. 1991). As far as JIT philosophy is concerned, quality circles have a great impact due to their objectives, the people who integrate them, and the leadership required. For instance, if issues with the movement and handling of materials arise, they may be solved or minimized by a quality circle.

2. *Total Quality Control*: Quality is an imputable feature of the product and has several attributes, which means that it is measured by various properties of the product. These properties must be controlled throughout the entire production

process. If a product does not meet any of these characteristics or attributes, it can be considered defective and will not be accepted in the market by the customer. Quality must be first analyzed in the production process, since this process concentrates all the activities that add value to a product or focus on obtaining the desired characteristics. However mistakes can occur during any stage of the production; thus, the piece of product affected would be unable to continue with the regular flow and would undergo additional activities to correct the defects and provide the characteristics desired for the product. As a result, the continuous flow of material would be interrupted and the goals of JIT philosophy would not be achieved.

The impact of quality programs on JIT has previously been studied. For instance, Withers et al. (1997) associated total quality management (TQM) and JIT with companies holding or having held quality certifications according to ISO standards. However, Vuppalapati et al. (1995) extended the research and stated that these two tools could not be applied independently, since they are interdependent. More recently, Cua et al. (2001) added a third variable to the relation and associated TQM, JIT, and programs of Total Productive Maintenance (TPM), which were considered essential to obtain proper performance and efficiency indicators in companies. Finally, a more general study was provided by Ahmad et al. (2012); it addressed several lean manufacturing tools and discussed their association with total quality programs and JIT.

3. *Statistical quality control*: In a quality system, numbers and statistics generated by the same system are the real indicators of the status of companies. Companies may rely on sophisticated quality control programs, but the interpretation of their results can still be inadequate. Numbers is the natural language of business and, in any company, this language is represented with the results shown by the production process. Statistical quality control in companies is a snapshot of their health. Thus, if the quality is not adequate, products or subassemblies cannot continue their normal flow, and the goals of JIT may be compromised.

   To implement a program of statistical quality control, companies must be familiar with all the characteristics desired for the product. This can be achieved through proper planning (Sengupta et al. 1993). Thus, only when the objectives to be achieved are known, it is easy to associate them with just-in-time programs (Yasin et al. 1997). For example, Fullerton and McWatters (2002) discussed different techniques of lean manufacturing, as well as the impact of these techniques over the level of maturity of a just-in-time implementation. Authors mentioned that appropriate plans and programs of quality control along with their application in the production process by statistical quality control are essential to the continuous flow throughout the supply chain and one of the key success factors of JIT.

4. *Quality development program*: JIT philosophy is part of the quality development program of a company, since it seeks to eliminate waste throughout the production process. Therefore, meeting these objectives is also part of the

development of the company as a profit organization. It seems impossible to apply without quality and business development programs. This means that JIT programs are a means to easily obtain the quality sought. Moreover, the idea of generating quality development plans is not a recent topic of research, since they are clearly linked with the performance indicators of a company (Valmohammadi and Roshanzamir 2015; Cua et al. 2001). However, it is accepted that product quality depends not only on machinery and equipment, but also on the education and training of managers who develop plans and workers who execute these plans (Sila 2007; Ooi 2014). Hence, a quality program must be closely linked to education and training programs.

5. *Continuous quality improvement*: As mentioned above, the quality of a product depends on the production process, but above all, it relies on the ability and skills of human resources. A quality plan or program should include strategies for continuous quality improvement, since no product is totally perfect; all products can be improved. Continuous quality improvement is mainly supported by two concepts, quality circles and Kaizen events (Knechtges and Decker 2014), where it is intended that workers or operators solve problems arising in the production lines. However, these improvements in quality depend to a great extent on the culture of these workers and their knowledge of the activities carried out in the production process (Choo et al. 2015). In other words, continuous improvement can only be understood after a suitable education program. Accepting that a product meets all specifications is being sure that there is no possibility to improve it. If these programs of continuous quality improvement are properly executed, they will always target at the elimination of waste throughout the supply chain and, therefore, companies will benefit from a better group of materials that facilitates the success of a JIT program. Recent studies reported economic aspects related the human factor and its impact on continuous improvement (Helander and Burri 1995).
6. *Zero defects*: When Crosby mentioned a program of zero-defect production in the arms industry in the United States, he knew that defects had to be corrected if the product could be saved or because discarding them would imply great economic costs. Thus, he believed that it was best not to make mistakes. However, reaching the goal of zero defects is almost impossible (Stroebel 1993), and many programs nowadays, such as such as Six Sigma philosophy (Love et al. 1995), focus primarily on obtaining acceptable quality rather than flawless quality. To achieve acceptable levels of quality and, as far as possible with zero defects, improvement programs should be based on education for all operators and the entire organizational structure (Westkämper and Warnecke 1994). Nevertheless, companies should also make use of their equipment and technologies to test quality to keep an adequate monitoring system throughout the entire production process. Fortunately, information and communication technologies today are able to achieve this. Similarly, producers must be very clear and specific when establishing guarantees, since the products can fail not just because of a mistake made during the manufacturing process, but also because a certain component may have completed its life cycle

(Myklebust 2013). Thus, companies could benefit from a continuous flow of materials throughout the production process when they focus on achieving zero defects in the production process. As a result, all products will be just-in-time delivered.

7. *Quality-oriented training*: This book has often mentioned the importance of JIT training and the impact of education and skills from operators on the production line and managers and supervisors on the senior and middle management. Quality-oriented training emphasizes on the fact that companies must guide training and education not only toward quality of both the product and production process, but also toward the people and their quality of life. A program of education and training oriented to quality would improve the work of employees as well as their everyday life. They would feel proud of the company they work for.
   The role of training and education in many of the techniques and tools of lean manufacturing has been extensively studied (Chryssolouris et al. 2013); however, companies nowadays require specific knowledge of advanced technologies for training and education due to their rapid change and modernization (Mital et al. 1999). Some universities and colleges now propose a number of courses that students must pursue in industries. That is, students must develop real projects in companies, which in turn grade them in the project. In some countries, such as Mexico, the government finances postgraduate programs to be pursued both inside the University and within the industry. These mixed programs seek to ensure the formation of people with high academic and scientific levels, but also practical skills. These educational programs always focus on the quality of the products and services offered. Thus, quality-oriented training ensures the fulfillment of the objectives of JIT.
8. *High visibility of quality control*: Accomplishments related to quality and all indices and metrics that represent the efficiency of the company, must be highly visible so that all operators can be familiar with the status of their workplace. This is very important because in many companies senior managers are usually the only ones acquainted with quality and efficiency statistics. This may be a mistake, because operators are not at least informed. However, some other companies tend to place neon signs indicating the number of defects detected in a shift. The sign is visible to all employees, which allows operators and supervisors to make an effort to reduce these defects.
   Similarly, not only bad news must be reported; the achievements of a company ought to be informed through different media. For instance, announcing the completion of a shift with zero defects can surely motivate employees to continue working toward this goal. When this kind of information is shared with workers in the production line, it helps keep them informed in and make decisions, both in real time. Some authors recommend planning the system to inform results from the moment facilities of the workplace are designed, since this would guarantee the expected results. When unplanned, the announcements are usually hung around the facilities or put in a place that was not designed for

that purpose at all (Colledani et al. 2014). It shall not be forgotten that not only quality issues must be available to workers. Instructions and the status of the production system, such as a product delay, must be visual to all. This improves the flow of raw materials throughout the production system and helps identify the biggest wastes, which is why it is considered as an element of JIT. Companies would be unable to find a production target or goal if workers are not familiar with the system at any time.

9. *Long-term commitment to QC*: Product quality is not achieved overnight; it is the result of hard work over many quality plans, which agrees with the principles of JIT. Both JIT and quality are philosophies applied to production systems, and philosophies are not implemented within a short time since they must be integrated into the lifestyle of workers. Therefore, quality must be the product of plans previously established by the top management, since it is responsible for setting the parameters and desirable attributes in the products or services offered. This form of ensuring quality is not new (Shturtz 1992). Some authors even recommend that companies have their own quality laboratory, so supervisors and workers themselves are responsible for quality control (Roderick and English 1990). Similarly, a more recent element has been discussed, the fact that quality planning ought to integrate environmental aspects to demonstrate how companies could get rid of products with polluting components (Madu et al. 1995). Surely, then, a long-term quality plan can help generate strategies to eliminate waste in the production system, which would increase fluidity of materials since the defective subassemblies would not remain in it.
10. *Regulate quality and reliability of audits*: A successful quality program must be actually executed, instead of being a beautiful book in a file cabinet. Quality should be a philosophy of production, but this is not always achieved. Therefore, companies should continuously perform a series of audits to analyze and detect deviations related to the plans established. A quality program without follow-up will most likely have a number of deviations in a short time, and these deviations tend to be difficult to correct and could consequently imply economic cost for the company, and companies are set to generate capital.

    It should be mentioned that quality audits do not generate quality; they merely indicate the status of a company in relation to a product or process. On the one hand, it is recommended that, in order to maintain standards and high-quality levels, audits must be conducted by experts who are fully acquainted with the desired characteristics of the product (Power and Terziovski 2007). On the other hand, other authors recommend that audits be performed by personnel outside the company, which preferably have no relation to the heads of the quality department to avoid complicity and concealment of errors (Kouaib and Jarboui 2014). Finally, it should be mentioned that no audit is sufficient to ensure product quality (Taggart 2013; Powell et al. 2013), and they always ought to be performed, especially when there are critical points or high risks. Therefore, an audit would help quickly detect errors and waste in the production process so they can be addressed as soon as possible to prevent defective products on the market or the stoppage of production system due to internal faults, which could generate late deliveries to customers.

11. *Quality culture*: As previously stated, quality is obtained as a result of education and culture; yet, reaching it demands great conceptualization and awareness. Indeed, while manufacturing quality products costs nothing, poor quality or no quality at all implies high costs, and one of them is failure to achieve just-in-time deliveries (Janipha and Ismail 2013). This failure may contribute to a bad reputation for the company.
An important work addressing the culture of quality emerged in Detert et al. (2003), which proposed to generate an index point to indicate the degree or level of quality culture in a company; yet, this may be further studied, since there seems to be a direct relationship between quality culture and operational and financial performance indexes (Roldán et al. 2012). However, it should be stressed that a culture of quality is the responsibility of top managers and operators, who are the primary reflection of the culture that exists in the company. As a summary, while senior management is responsible for the development, monitoring, supervision, and control of quality plans and programs, employees are responsible for the successful execution of these.
12. *100 % quality inspection*: The inspection of all raw materials arriving in the warehouses may not be a proper approach, since it is assumed that companies only order acceptable and high-quality components. The quality of these components is the responsibility of the manufacturer. The cost of a 100 % inspection is very high, and it does not guarantee first quality products, although it helps detect those who do not meet specifications. However, it may be more suitable if every operator performed an inspection of his/her corresponding raw materials and became responsible for the operations that he/she must execute. Moreover, it may not be desirable to count on an inspection section within a production line. It might be more appropriate if each activity could be checked by the person in charge. This could ensure a more effective and rapid 100 % inspection, which guarantees that the components or raw materials entering the production process are free from defects and problems related to product quality will not emerge in subsequent activities. This ensures a continuous flow of materials along the system and just-in-time deliveries.
Fortunately, a number of technologies nowadays help conduct 100 % quality inspections within the production process, and they are all supported by sophisticated computer equipment (Xie et al. 1998). As a result, ensuring quality can sometimes be a process that is fully automated by vision systems (Lee and Park 2000).
13. *Simplify the process of total quality*: Product quality is not warranted with a sophisticated program. It is frequently mentioned that quality programs must be straightforward, which indicates that a company has fully accepted quality as a production philosophy. A quality management system is often mistaken with the quality philosophy itself, since quality control is not an easy task and workers usually know little of it since they fear their complexity (Dooley and

Flor 1998). The previous page referred to an index to measure quality culture in companies, and perhaps simplification of the quality process is a valid index. It is true that during the production process, companies must draw upon documentation and survey statistics to identify areas of opportunity for improvement. Nevertheless, if a product is incorrectly processed at some point of the production process, and it can be corrected by the operator who detected the issue, the easiest and perhaps most logical decision would be to correct it so the product does not continue in the production line. However, it is required for administrative purposes to count and record such errors, since they may indicate the need of a training program for the person in charge of the activity (Forza and Filippini 1998). This proposes two scenarios, one in which quality assurance is simplified by correcting an identified effect, and another in which companies issue an administrative act to take corrective actions. It is likely that both be necessary to ensure product quality in the future. If the report is not issued, the problem may not be solved from its roots, and the error may continue to appear.

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