Integrating corporate social responsibility and quality management into the TDABC costing system: a case study in the assembly industry

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Abstract

Purpose – *This paper aims to show the potential of time-driven activity-based costing (TDABC) to value and integrate corporate social responsibility (CSR) and quality management (QM) processes in the assembly industry. It provides valuable insights about operational processes, sub-process and activities within assembly companies by using TDABC's time equations with more accurate costs for the decision-making process.*

Design/methodology/approach – *The current paper proposes a new methodology framework with four QM and CSR implementation levels and several costing scenarios through the TDABC system. The valuation was built based on the activities of essential referents in each subject, such as ISO, Ethos Institute and electrostatic discharge control programs. To this end, a case study in the assembly industry processes was conducted with data from a TV assembler.*

Findings – *The results highlight that TDABC can be extended to perform a cost analysis with QM and CSR processes. The environmental management and occupational safety and health administration processes were considered part of CSR to do so. Consequently, managers can simulate the cost and impact of incorporating CSR and QM in assembly processes and thus decide the implementation degree and its corresponding planning according to the needs and available resources. In this particular case, the company increases a maximum of 12% of its resources to be socially responsible and manage its products' quality.*

Originality/value – *Although theoretical models on CSR have been developed, the current study provides a practical framework based on TDABC scenarios that enterprises can easily implement to support and evaluate QM and CSR processes.*

Keywords *Quality management, Corporate social responsibility, TDABC, Time-driven activity-based costing, Assembly industry*

Paper type *Case study*

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1. Introduction

Nowadays, corporate social responsibility (CSR) has become an emerging trend for the industry, academia, government and other organizations. Different CSR standards have been implemented, such as ISO 26000 and OECD guidelines (International Organization for Standardization (ISO), 2010; Organization for Economic Co-operation and Development (OECD), 2011). In addition, the global reporting onitiative (GRI) organization and the Ethos Institute provide a set of indicators to evaluate the level of CSR compliance for sustainable and responsible business (Ethos Institute, 2019; Global Reporting Initiative: GRI Standards, 2016). According to the European Commission (EU) Green Paper, CSR integrates economic, environmental and social dimensions in the companies' business operations, including interactions with their stakeholders voluntarily (Commission of the European Communities, 2001). Furthermore, the triple-bottom-line concept, introduced by Elkington (2002), can create economic value for organizations by paying attention to social justice, environmental quality and social well-being (Gorenak, 2015).

Nevertheless, as the notion of a business and a company is always related to a profit, linking these two perspectives, i.e. CSR and economic value of the company, becomes highly essential. For instance, some CSR practices, such as reducing waste or formalizing internal processes, influence operational efficiency and thus make production more cost-effective while increasing profits (Księżak, 2017). Furthermore, CSR policy may improve the company's financial performance because some governments offer tax benefits for socially responsible behavior, thus contributing to the well-being of workers and the whole society (Perry and Towers, 2013).

The integration of quality, environmental, occupational health and safety (OHS) and social responsibility gives a competitive advantage to organizations (Stanciu *et al.*, 2017). As time progresses, an increasing interdependence in CSR and quality management (QM) can be noticed (Gorenak, 2015). Most CSR principles are coherent to ISO 9001 (International Organization for Standardization, 2015a), such as continuous improvement, organizational commitment, society/stakeholders' needs and afford organization sustainability and business excellence (Frolova and Lapina, 2014). In this sense, considering quality options offers valuable perspectives for achieving the companýs objectives. Philosophies like total quality management (TQM) and ISO 26000 make a special connection between people and QM systems (Gorenak, 2015). These philosophies suggest dimensions ranging from human resources management to the supplier's control (Gómez *et al.*, 2017) and with specific guidance for human rights, labor practices, consumer issues and the involvement and development of the community (Sitnikov and Bosean, 2015). ANSI/ESD S20.20 is another measure that contributes to a more competitive organization on quality. This standard pursues quality assurance by controlling electrostatics processes in the industry (Electrostatic Discharge Association (ESDA), 2014). ISO 26000 is also a reference standard for environmental management (EM) ISO 14001, whose principles support sustainability pillars (International Organization for Standardization (ISO), 2015b). The application of ISO 14001 can benefit both the company and the environment (Campos *et al.*, 2015). Additionally, OHS ISO 45001 is another set of fundamentals reaching positive impacts on companies through human resource management (International Organization for Standardization (ISO), 2018). Together with ISO 9001 and ISO 14001, this basis describes some management systems capable of accomplishing sustainable purposes.

The economic dimension of CSR focuses on maximizing the benefit of companies and thus of shareholders, on the one hand, and their growth, on the other (International Organization for Standardization (ISO), 2010). Similarly, the economic essence of a quality approach targets business excellence (Androniceanu, 2017). Therefore, it is vital to have effective and efficient cost systems (Medeiros *et al.*, 2017) that contribute to making sound decisions and the economic end of the company. Although the traditional cost system is the most popular accounting technique applied by industry (Li *et al.*, 2012), advanced costing techniques are more suitable to achieve efficiency, profit increase and continuous improvement (Zamrud *et al.*, 2020). This is the case of the time-driven activity-based costing (TDABC), developed by Kaplan and Anderson in 2004 (Kaplan and Anderson, 2007). TDABC system represents an enhanced version of the former activity-based costing (ABC) (Tanis and Özyapici, 2012) since it can provide timely and accurate information at a lower maintenance cost. It also propitiates a straightforward data interpretation (Medeiros *et al.*, 2017). TDABC aims not only to allocate overhead costs accurately but also to identify areas of waste (Li *et al.*, 2012). Together with other techniques, such as lean management, this costing method seeks to reduce waste at the process level and boosting process improvements

(Kaplan and Anderson, 2007). Unlike TDABC, traditional costing systems are not enough to meet the need for conducting capacity utilization analyses since they allocate overhead costs to products based on a volume-based cost driver (Adıgüzel and Floros, 2019). Also, ABC considers that the processes operate at their total capacity without considering the idle and unused time (Kaplan and Anderson, 2007). Meanwhile, the cost of idle capacity and capacity management is a central problem in operations and production systems (Santana *et al.*, 2017; Todorovic and Cupic, 2017). By considering all these TDABC advantages, the possibility of including CSR and QM aspects can contribute to a broader outlook in the application of the cost system.

Most of the previous analyses were oriented to implement CSR and QM, focusing on processes, people and benefits. However, there is a research gap in visualizing the cost of their implementation to support management decisions. Therefore, the current article shows the potential of TDABC to value CSR and QM processes in the assembly industry through the integration of these dimensions. Also, the study is oriented to extend TDABC application in the assembly industry due to the limited number of studies performed in this area. Finally, this research paper answers the question:

RQ1. How can CSR and QM processes be analyzed using the TDABC costing system?

To this end, an analysis of different costing scenarios, integrating the three dimensions: social, environmental and economic, was performed by using TDABC's time equations. The rest of this document is organized as follows. Section 2 is oriented to identify the most influential investigations in the field of study. The applied methodology is explained in Section 3. The main results and their corresponding discussion are exposed in Section 4. Finally, conclusions and recommendations for future research are formulated in Section 5.

2. Literature overview of time-driven activity-based costing applications

According to Musov (2017), TDABC is a combination of the traditional cost system (the cost per time unit of capacity) and the simplified ABC approach (the computation of the cost-driver rates). TDABC shortens the costing process using time equations to drive costs directly from resources to cost objects. It is only based on two parameters: the cost per unit of time of the supplied capacity of resources (capacity cost rate) and the estimated time required for each activity (Kaplan and Anderson, 2007). Time equations may include all particular aspects and variations in selecting activities in the company's database (Kustono and Agustini, 2019). Thus, TDABC offers simple integration into the management system and provides timely and accurate information, lower maintenance costs and straightforward data interpretation (Santana and Afonso, 2015).

In the literature, TDABC has been proved in many industries or businesses and different environments (Santana and Afonso, 2015). Furthermore, some research shows that TDABC provides benefits such as simplicity in its application, adjustment to the processes' complexity, more precise allocation of costs, estimation of used capacity and idle capacity, information on process improvement and analysis of orders and customer profitability (Siguenza-Guzman *et al.*, 2013). Thus, Kaplan and Anderson (2007) assert that TDABC can be appropriate in most organizations, regardless of customer complexity, products, channels, segments or processes. Also, Everaert *et al.* (2008) emphasized this idea by affirming that TDABC has broad applicability, given the number of researches done so far.

Although Öker and Adigüzel (2010) affirm that TDABC is more suitable for service companies, Nik Mohd Kamil *et al.* (2020) confirm its successful application in manufacturing companies. In addition, Barros and Ferreira (2017) have implemented TDABC in the frozen food sector and found that this model is feasible and suitable for production environments and can deal with the variability of processes. The authors' only limitation was that the lack of historical data and practices did not allow recording the time in some departments; consequently, transportation, maintenance and sales processes were excluded. Reynolds *et al.* (2018) performed research in polyvinyl chloride and canvas production, where TDABC approach helped to identify two critical problems in the factory, namely, high expenditure and unused capacity. Also, Meric and Gersil (2018) reported that TDABC is helpful to determine the idle capacity and the budgeting process in the air suspension of an air spring factory. Adıgüzel and Floros (2019) found that capacity analysis through TDABC provides two opportunities to companies: more accurate information on product costs and improvement of operational efficiency by reducing idle capacity, either by increasing production volume or eliminating unused resources. According to Anderson (2020), inadequate resources represent significant delays and depletion of other resources. In the food industry, Kustono and Agustini (2019) determined that calculations with TDABC provide more accurate information compared to the traditional costing system due to the charging of factory overhead costs per product. Mohd Safeiee *et al.* (2020) concluded that TDABC is well suited for the manufacturing industry because it is one of the best tools for understanding cost behavior and to refining a costly system. The authors also highlighted its contribution to maximizing efficiency and effectiveness throughout the production system, cost and eventually increasing net income.

Despite the high number of contributions documenting the TDABC implementation in the industrial sector, few studies regarding the assembly industry are available. Ganorkar *et al.* (2018) suggested TDABC identify opportunities for low-cost assembly solutions and improve the system's productivity in the production of furniture for hospitals and homes. Soufhwee *et al.* (2019) reported that TDABC is more accurate and faster than ABC, using an enhanced decision-making process and supporting the organization's manufacturing system of a real assembly line in the automotive industry. Also, Ghani *et al.* (2020) had good results from the TDABC application into the same type of production to identify used or underused capacity and for a better investment strategy. The authors affirm that TDABC is a powerful tool to analyze the actual condition of production. Vedernikova *et al.* (2020) highlighted that the TDABC benefits extend beyond the unit cost determination, allowing to understand the business dynamics in a more in-depth and more detailed manner through consideration of sub-processes and activities.

Few studies have been published in the literature on efforts to develop decision support methods or tools incorporating CSR or QM aspects into business operations. One study, reported by Durán *et al.* (2020), built a model to analyze the use of maintenance capacity by examining maintenance activities costs in a mining industry plant. The authors integrate life-cycle costing aspects in TDABC models to generate costing scenarios based on different maintenance strategies and the life-cycle stage of plant machinery, which allowed estimating future costs of the maintenance strategies considered. Nhaili *et al.* (2016) proposed a new approach to evaluate the effectiveness of maintenance processes by using TDABC and lean thinking to analyze possible improvements. The method used is similar to Durán *et al.* (2020), where activities of the maintenance department are mapped and enhancements were established by using a lean maintenance strategy to reduce delays, times and calculating cost savings using TDABC. Likewise, Yang C-H *et al.* (2020) proposed a decision support model based on ABC and multicriteria decision-making (MCDM) to determine portfolio strategies for information systems in the health care industry. In this manner, the authors can establish optimal strategies to select systems based on the cost estimation of design, installation, operation and improvement activities.

Regarding CSR, Wen-Hsien and Jui-Ling (2008) proposed the combination of decision-making trial and evaluation laboratory, analytic network processes and zero one goal programming to develop a model to support the selection of CSR programs in the airline industry. The article shows an application example by determining the costs of selected CSR programs for a case study. In addition, it performs a comparison with fuel reduction strategies. A different approach is presented by Jourdaine *et al.* (2021), which detailed the integration of life cycle assessment and ABC to develop a model to estimate financial costs and the associated environmental impacts of a production process in a simplified case study. Nonetheless, the mentioned article focused on quantifying environmental impacts only, in addition to costs to support decision-making by including environmental criteria. As can be noticed, the reported efforts focus on one specific quality or CSR aspect, such as maintenance, environmental impacts or improvements. Unfortunately, addressing the implementation costs of both QM and CSR has not been reported. A theoretical model incorporating CSR, QM and TDABC elements in process management by using business process modeling notation (BPMN) was developed by Sigcha *et al.* (2020). This study also contributed theoretical knowledge to introduce OHS and the environmental dimension as part of CSR. Nevertheless, it does neither clarify how TDABC can be applied in a real case study nor how to obtain the calculations of the process costs. All in all, it can be conjectured that there is a scarce exploration on the use of current costing methods such as TDABC to support CSR or QM implementation in companies.

3. Materials and methods

In this section, the methodological design of this work is outlined. To this end, the selection of CSR and QM elements is described. Next, the creation of costing scenarios is detailed. Finally, the last part proposes the TDABC calculation methodology.

3.1 Methodological design

To develop the present work, a case study analysis was applied. The selected case study corresponded to an assembly company that produces 14 different TV models in Ecuador. The production process is primarily manual, i.e. its assembly line's automation level is low and few specialized types of equipment are used. The case study was selected based on the researchers' convenience in the accessibility and proximity of the subjects, as suggested by Otzen and Manterola (2017). This allowed understanding complex organizational phenomena, providing more convincing evidence than a single case (Yin, 2003). However, due to a confidentiality agreement, the present study does not reveal the company's name and other specific information on its products.

The comparative study focused on the assembler's operational processes (TV assembly and Warehouse). The reasoning behind this is that TDABC has certain limitations in analyzing the strategic and support processes due to their low standardization and irregularity (Vedernikova *et al.*, 2020). The TDABC application requires various inputs, such as processes and activities data, times per activity, resources and annual or monthly frequencies per activity. For this reason, the data collection was achieved in five steps:

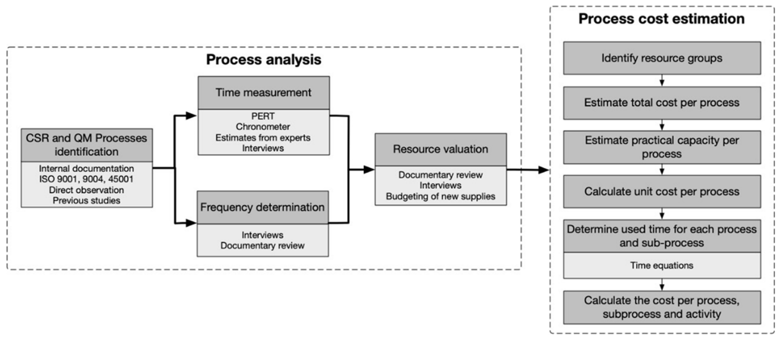
1. identification of operational CSR and QM processes;
2. measurement of time;
3. determination of frequencies;
4. identification of resources; and
5. estimation of process costs, as shown in Figure 1.

These steps required the analysis of documentary evidence, periods of direct observation, time-by-activity studies and semi-structured interviews with the staff.

3.2 Corporate social responsibility and quality management processes

To consider CSR and QM aspects into TDABC, important standards (e.g. ISO9001, ISO9004 and ISO 45001), the local regulations of Ecuador, manuals and TV brand specifications were reviewed as secondary information. The identification of CSR and QM elements followed a documentary analysis of factors. First, primary info such as the

Figure 1 Method design for the incorporation of QM and CSR into the TDABC methodology



***Note:** PERT = program evaluation and review technique

company's internal documentation was obtained and reviewed. This activity aimed to identify the existing processes regarding QM and some CSR practices. In addition, direct observation allowed verifying the number of employees per activity and visualizing the sequence of operations and events. Next, CSR and QM elements from the operational setting were identified from strategic processes. This action allowed distinguishing specific processes according to the production stream to offer essential information for the subsequent calculations. Later, self-assessment tools for CSR and QM implementation validated by experts in industrial engineering were used to determine:

- current practices within this company; and
- a new set of activities adapted to its characteristics.

Regarding the scope of QM and CSR management and based on previous studies (Sigcha *et al.*, 2020), it was determined that the CSR aspects directly involved with operational processes in assembly companies are environment and OHS. The rest of the CSR dimensions belong to strategic operations. Therefore, the analysis of assembly processes, enterprise data and findings from Vedernikova *et al.* (2020) was used. Subsequently, this previous study was integrated with current CSR and QM activities.

After the process identification, time measurement of selected processes was carried out through interviews, observation, chronometer reading, expert consultation and estimates from similar companies. In cases where it was impossible to physically measure the times of the activities (mainly for CSR), meetings with experts were applied per topic.

In addition, the program evaluation and review technique (PERT) (Kerzner, 2003) was used to establish the expected time based on equation (1) due to effectiveness to obtain and improve a critical path of a list of activities. Thus, the PERT technique helped create more realistic schedules and cost estimates based on the shortest and the longest possible time each activity takes:

$$Expected\ \ time = T_{min} + 4T_{avg} + T_{max} \tag{1}$$

where:

T_{min} = is the minimum time to perform an activity;

T_{avg} = is the average time to perform an activity; and

T_{max} = is the maximum time to perform an activity(1).

At the same time, frequencies and periodicity of processes were obtained through interviews, preliminary documentation review and local regulations analysis to determine how often activities are carried out monthly. Before estimating the processes costs, the valuation of inputs and resources must be obtained for each activity to be analyzed. These estimates were performed through documentary reviews, analysis of local regulations, interviews and budgeting of new supplies to identify all the cost elements required during the process development.

Finally, the last step analyzed primary and secondary data through TDABC costing matrices to build graphs and Pareto diagrams supporting the decision-making process. This analysis allowed a practical model with four operational settings CSR and QM implementation levels for several costing scenarios.

3.3 Design of the costing scenarios

The previous research of Sigcha *et al.* (2020) was implemented to develop costing scenarios. The authors present a model incorporating the elements of CSR and QM in a process management platform that uses BPMN and TDABC. They also introduce occupational safety and health (OHS) and environmental processes as a part of CSR.

The current study uptakes QM, EM and occupational safety and health administration (OSHA) processes into a TDABC costing model to improve quality and CSR. To this end, the study proposed a definition and simulation of levels or scenarios to value these processes and support decision-making. These scenarios were based on the current practices of the case study, local legislation, ISO norm, Ethos and additional standard guidelines. The proposed levels are depicted in Table 1. A revision of standards and the application of assessment tools in the case study was carried out to establish the activities and processes per cell (i.e. for each level and each matter). For example, Level 0 assumes that no operations or activities are related to QM, OSHA and EM. This means that the enterprise only focuses on operational processes without considering CSR and quality aspects. Concerning Level I, the processes were selected according to local regulations and brand requirements to identify the current practices in the company. On Level II, the processes were proposed based on recommendations from well-known CSR and TQM guides and standards, such as ISO 9001, ISO 9004, ISO 45001 and Ethos indicators. Finally, for Level III, new processes and activities were proposed to incorporate suggested practices, according to ISO 26000 and ISO 14001 guidelines. For QM, a set of procedures is recommended based on the ANSI ESD S20.20 standard since it is adjusted to the case study's sector. It also offers an approach for preventing failures from electrostatic discharge (ESD) related to the manual handling of electronics components in the assembly sector (Tamminen, 2016).

According to Table 1, each process can have four levels of implementation, being Level III of higher hierarchy due to the increased complexity of the number of processes, sub-processes

Table 1 Levels of implementation for QM, OSHA and EM

		*SCR*****	
Level	*QM**	*OSHA***	*EM****
0	No QM processes or activities	No OSHA processes or activities	No EM processes or activities
I	Processes or activities required by local regulations and brands	Processes or activities required by local regulations (i.e. Ministry of Labor)	Processes or activities required by local regulations
II	Processes or activities based on ISO 9001 and ISO 9004	Processes or activities based on ISO 45000	Processes or activities based on Ethos
III	Processes or activities based on ANSI ESD S20.20	Processes or activities based on ISO 26000	Processes or activities based on ISO 26000 and ISO 14001

Notes: *QM = quality management; **OSHA = occupational safety and health administration; ***EM = environmental management and activities. The intersection of each matter and level allows having a large number of possible combinations; however, for space restrictions, the following three scenarios were considered in the present study:

1. Scenario 1: QM, OSHA and EM on Level I.
2. Scenario 2: QM, OSHA and EM on Level II.
3. Scenario 3: QM, OSHA and EM on Level III.

The new processes were identified by reviewing ISO, Ethos and ANSI ESD S20.20 documentation and regulations to analyze the costs of implementing CSR and QM in operational processes.

3.4 Time-driven activity-based costing calculation methodology

The TDABC calculation is based on the generic steps developed by Everaert *et al.* (2008) and Reynolds *et al.* (2018), as well as the methodology proposed by Vedernikova *et al.* (2020). The steps for estimating QM, OSHA and EM process costs are the identification of various resource groups, estimation of the total costs of each process (supplied resources), estimation of the practical capacity of each process, calculation of the unit cost of each process, determination of the time used in each process and sub-process and value of each process, sub-process and activity (used resources).

3.4.1 Identify various resource groups. As resource groups, the processes of QM, EM and OSHA were considered. These processes were classified into sub-processes and activities. The following codifications were made to facilitate the analysis, as shown in Table 2 and Appendix 1 for processes and activities.

However, these processes are not always completely independent of the other processes. For example, some QM and EM activities are carried out by the staff of other operational processes, such as TV assembly, TV Warehouse, External Maintenance, Environmental process and External Audit. Therefore, the resource allocation (Step 2), the estimation of practical capacity (Step 3) and the calculation of the unit cost (Step 4) were done according to the respective operational processes, as shown in Table 3.

Table 2 Codifications of processes, sub-processes and activities

Analyzed processes	*Sub-processes*	*Activities*	*Dimensions*
Quality management (QM)	QM1... QM7	AQM1... AQM27	QM
Occupational safety and health administration (OSHA)	OSH1... OSH8	AOSH1... AOSH37	CSR
Environmental management (EM)	EM1... EM6	AEM1... AEM21	

Table 3 Relation between analyzed processes and operational processes

Analyzed processes	*Operational processes*	*Sub-processes*	*Activities*	*Dimensions*
QM*	TV assembly	QM1... QM5, QM7	AQM1... AQM18, AQM23... AQM27	QM
	External maintenance	QM6	AQM19... AQM22	CSR****
OSHA**	Occupational safety and health administration	OSH1... OSH8	AOSH1... AOSH37	
EM***	TV warehouse	EM1	AEM1... AEM4	
	TV assembly	EM2	AEM5 ... AEM7	
	Environmental process	EM3... EM5	AEM8... AEM18	
	External environmental audit	EM6	AEM19... AEM21	

Notes: *QM = quality management; **OSHA = occupational safety and health administration; ***EM = environmental management; ****CSR = corporate social responsability

3.4.2 Estimate the practical capacity of each process. In the case of the employees, it was considered 80% of the theoretical capacity (hours worked per month) and 85% for machinery (Kaplan and Anderson, 2007). As a result, 19.58 days per month were obtained as the practical capacity of each process (Vedernikova *et al.*, 2020). Finally, the conversion of the days worked was performed according to payment role reports.

3.4.3 Estimate the unit cost of each process. This value was obtained by dividing Step 2 by Step 3. This estimation allowed to have the following costs:

$C_{TV\ assembly}$ is the unit cost of the TV assembly process.

$C_{TV\ warehouse}$ is the unit cost of the TV warehouse process.

$C_{External\ maintenance}$ is the unit cost of the external maintenance process.

C_{OSHA} is the unit cost of the OSHA process.

$C_{Environmental\ process}$ is the unit cost of the EM process.

$C_{External\ environmental\ audit}$ is the unit cost of the external audit process.

3.4.4 Determine the time used in each process and sub-process. This step was given according to the time (in minutes) and the frequencies of each activity determined with methodology explained in Section 3.2 and the time equations introduced by Kaplan and Anderson (2007) [Equation (2)]. Thus, specific time equations for QM, OSHA and EM processes were formulated based on activities indicated in Appendix 1 that correspond to a present case study in the TV assembly:

$$Process\ \ time = \sum\ of\ \ individual\ \ activity\ \ times = \beta_0 + \beta_1 X_1 + \ldots + \beta_i X_i \tag{2}$$

where:

β_0 = is the standard time for performing the primary activity;

$\beta_1\ \beta_i$ = is the time for the additional activities; and

$X_1\ X_i$ = are the frequencies for the additional activities.

3.4.5 Value each process, sub-process and activity. This was done by multiplying Step 3 by Step 4. The calculation was made in a totalized form and separately regarding direct labor, indirect labor and factory overhead:

$$Process,\ Sub-process\ and\ activity\ cost\ = \sum\ of\ individual\ C_{unit\ \ cost}\ *\ Time \tag{3}$$

The equations mentioned above allow calculating the times needed for the QM processes and their corresponding cost with the TDABC method and EM and OSHA processes as a part of CSR.

4. Results and discussion

In this research, the integration of CSR and QM through TDABC in the processes of a TV assembly company determined three main processes: QM, EM and OSHA. These processes involve 21 sub-processes and 85 activities. Table 4 shows its distribution for four levels and three scenarios analyzed from the methodological design of Table 1.

This segregation derives some results of interest, such as using and combining international relevant standards like ISO9001, ISO9004, ISO 45001, ISO 26000, ISO 140001 and ANSI ESD S20.20 to define practical scenarios of CSR and QM activities within operational processes. Also, the CSR and QM analysis considered the application of TDABC in the assembly industry. TDABC offers the benefits of calculating accurate cost on different

Table 4 Distribution of sub-processes and activities by levels and scenarios

Level	*Scenario*	*SCR*****							
		*QM**		*OSHA***		*EM****			
		# Sub-prosesses	*# Activities*	*# Sub-prosesses*	*# Activities*	*# Sub-prosesses*	*# Activities*	*Total # of sub-processes*	*Total # of activities*
0		0	0	0	0	0	0	0	0
I	Scenario 1	4 QM1…QM4	6	5 OSH1…OSH5	28	1 EM3	1	10	35
II	Scenario 2	6 QM1…QM6	22	6 OSH1…OSH6	34	4 EM1…EM4	14	16	70
III	Scenario 3	7 QM1…QM7	27	8 OSH1…OSH8	37	6 EM1…EM 6	21	21	85

Notes: *QM = quality management; **OSHA = occupational safety and health administration; ***EM = environmental management; ****CSR = corporate social responsibility

dimensions based on consumed time in performed activities. Therefore, managers can use this information to support decision-making on the degree of their implementation. In this study, only the cost of the QM, EM and OSHA processes was determined because costing with TDABC is more effective for regular and standard activities (Öker and Adigüzel, 2010). The activities of these processes can be introduced into the operational process (Table 3) in the assembly industry and be valued by the TDABC cost system. Other CSR elements belonging to the strategic activities have low standardization and are irregular. According to Vedernikova *et al.* (2020), their cost valuation is restricted by TDABC.

The proposed methodological framework gives a new approach to simulate and value QM and CSR operational processes in the assembly industry by three levels or scenarios. Therefore, the model of Sigcha *et al.* (2020) incorporating CSR into a process-based cost analysis system was enriched by applying TDABC and the formulation of specific equations (from 4 to 9) to the QM, EM and OSHA processes to value their time and cost:

$$\begin{aligned} Time\ \ QM = {} & Time\ \ AQM1 * X_{AQM1} + \ldots + Time\ \ AQM6 * X_{AQM6} + (Time\ \ AQM7 * X_{AQM7} \ldots \\ & + Time\ \ AQM22 * X_{AQM22})\{if\ \ Level\ \ 2\ \ or\ \ 3\} + (Time\ \ AQM23 * X_{AQM23} \ldots \\ & + Time\ \ AQM27 * X_{AQM27})\{if\ \ Level\ \ 3\} \end{aligned} \quad (4)$$

$$\begin{aligned} Time\ \ OSHA = {} & Time\ \ AOSH1 * X_{AOSH1} + \ldots + Time\ \ AOSH3 * X_{AOSH3} + Time\ \ AOSH7 \\ & * X_{AOSH7} + \ldots + Time\ \ AOSH22 * X_{AOSH22} + Time\ \ AOSH24 * X_{AOSH24} + \ldots \\ & + Time\ \ AOSH32 * X_{AOSH32} + (Time\ \ AOSH4 * X_{AOSH4} \ldots + Time\ \ AOSH6 \\ & * X_{AOSH6})\{if\ \ Level\ \ 2\ \ or\ \ 3\} + (Time\ \ AOSH23 * X_{AOSH23} + Time\ \ AOSH33 \\ & * X_{AOSH33} + AOSH34 * X_{AOSH34})\ \{if\ \ Level\ \ 3\} \end{aligned} \quad (5)$$

$$\begin{aligned} Time\ \ EM = {} & Time\ \ AEM8 * X_{AEM8} + (Time\ \ AEM1 * X_{AEM1} \ldots + Time\ \ AEM7 * X_{AEM7} \\ & + Time\ \ AEM9 * X_{AEM9} \ldots + Time\ \ AEM14 * X_{AEM14})\{if\ \ Level\ \ 2\ \ or\ \ 3\} \\ & + (Time\ \ AEM15 * X_{AEM15} \ldots + Time\ \ AEM21 * X_{AEM21})\{if\ \ Level\ \ 3\} \end{aligned} \quad (6)$$

$$\begin{aligned} Cost\ \ QM = {} & C_{TV\ \ assembly} * (Time\ \ AQM1 * X_{AQM1} + \ldots + Time\ \ AQM6 * X_{AQM6} \\ & + (Time\ \ AQM7 * X_{AQM7} \ldots + Time\ \ AQM18 * X_{AQM18})\{if\ \ Level\ \ 2\ \ or\ \ 3\} \\ & + (Time\ \ AQM23 * X_{AQM23} \ldots + Time\ \ AQM27 * X_{AQM27})\{if\ \ Level\ \ 3\}) \\ & + C_{External\ \ maintenance} * (Time\ \ AQM19 * X_{AQM19} \ldots + Time\ \ AQM22 * X_{AQM22}) \\ & \{if\ \ Level\ \ 2\ \ or\ \ 3\} \end{aligned} \quad (7)$$

$$\begin{aligned} Cost\ \ OSHA = {} & C_{OSHA} * (Time\ \ AOSH1 * X_{AOSH1} + \ldots + Time\ \ AOSH3 * X_{AOSH3} \\ & + Time\ \ AOSH7 * X_{AOSH7} + \ldots + Time\ \ AOSH22 * X_{AOSH22} + Time\ \ AOSH24 \end{aligned}$$

$$* X_{AOSH24} + \ldots + Time\ \ AOSH32 * X_{AOSHM32} + (Time\ \ AOSH4 * X_{AOSH4} \ldots + Time\ \ AOSH6 * X_{AOSH6})\{if\ \ Level\ \ 2\ \ or\ \ 3\} + (Time\ \ AOSH23 * X_{AOSH23} + Time\ \ AOSH33 * X_{AOSH33} + AOSH34 * XA_{AOSH34})\{if\ \ Level\ \ 3\}) \tag{8}$$

$$Cost\ \ EM = C_{Environmental\ \ process} * Time\ \ AEM8 * X_{AEM8} + (C_{\ TV\ \ Warehouse} * (Time\ \ AEM1 * X_{AEM1} \ldots + Time\ \ AEM4 * X_{AEM4}) + C_{\ TV\ \ Assembly} * (Time\ \ AEM5 * X_{AEM5} \ldots + Time\ \ AEM7 * X_{AEM7}) + C_{Environmental\ \ process} * (Time\ \ AEM9 * X_{AEM8} \ldots + Time\ \ AEM18 * X_{AEM18})\{if\ \ Level\ \ 2\ \ or\ \ 3\} + C_{External\ \ environmental\ \ audit} * (Time\ \ AEM15 * X_{AEM15} \ldots + Time\ \ AEM21 * X_{AEM21})\{if\ \ Level\ \ 3\} \tag{9}$$

Furthermore, these equations can be extended to new operational QM and CSR activities from the current case study or adapted to other organizations by adding new variables (N activities) to each scenario as shown below in the EM process example [equations (10)–(11)]:

$$Time\ \ EM = Time\ \ AEM8 * X_{AEM8} + \boldsymbol{Time\ \ AEMN * X_{AEMN}} + (Time\ \ AEM1 * X_{AEM1} \ldots + Time\ \ AEM7 * X_{AEM7} + Time\ \ AEM9 * X_{AEM9} \ldots + Time\ \ AEM14 * X_{AEM14} + \boldsymbol{Time\ \ AEMN * X_{AEMN}})\{if\ \ Level\ \ 2\ \ or\ \ 3\} + (Time\ \ AEM15 * X_{AEM15} \ldots + Time\ \ AEM21 * X_{AEM21} + \boldsymbol{Time\ \ AEMN * X_{AEMN}})\{if\ \ Level\ \ 3\} \tag{10}$$

$$Cost\ \ EM = C_{Environmental\ \ process} * (Time\ \ AEM8 * X_{AEM8} + \boldsymbol{Time\ \ AEMN * X_{AEMN}}) + (C_{\ TV\ \ Warehouse} * (Time\ \ AEM1 * X_{AEM1} \ldots + Time\ \ AEM4 * X_{AEM4} + \boldsymbol{Time\ \ AEMN * X_{AEMN}}) + C_{\ TV\ \ Assembly} * (Time\ \ AEM5 * X_{AEM5} \ldots + Time\ \ AEM7 * X_{AEM7} + \boldsymbol{Time\ \ AEMN * X_{AEMN}}) + C_{Environmental\ \ process} * (Time\ \ AEM9 * X_{AEM8} \ldots + Time\ \ AEM18 * X_{AEM18} + \boldsymbol{Time\ \ AEMN * X_{AEMN}}) \{if\ \ Level\ \ 2\ \ or\ \ 3\} + C_{External\ \ environmental\ \ audit} * (Time\ \ AEM15 * X_{AEM15} \ldots + Time\ \ AEM21 * X_{AEM21} + \boldsymbol{Time\ \ AEMN * X_{AEMN}})\{if\ \ Level\ \ 3\} \tag{11}$$

The process cost and time estimation were performed after the operational QM, EM and OSHA process analysis (classification into sub-processes and activities, frequencies and time equations). The findings indicate that QM is the most expensive process for the three scenarios (Figure 2) and the most time-consuming (Appendix 2). Meanwhile, OSHA is the second-highest for time consumption. However, in Scenario 3, EM processes use more resources than OSHA processes due to an additional and expensive sub-process EM6 Performing environmental audit. Therefore, TDABC allowed estimating the costs and time necessary for introducing CSR and QM processes based on the needs and resources available in the TV assembly company (Table 5 and Appendix 3).

Another important finding is that introducing these elements does not require significant investments in the analyzed company. To achieve Scenario 3 (the maximum cost level), only a 12% increase in the used resources is recorded compared to the resources used for the current production process (US$636,834). They are distributed in the following manner 9% for QM, 2% for EM and only 1% for OSHA. In Scenario 2, the results are the same, except for the EM process, which only reaches 1%. While in Scenario 1, the increase is 7%, 1% and close to 0%, respectively, for each process analyzed (Figure 3).

In the present study, the integration of these three aspects (i.e. QM, OSHA and EM) to the operational processes of TV Assembly and TV Warehouse does not affect its practical capacity. As recommended by Kaplan and Anderson (2007), it has proceeded with the maximum increase of 3.5% to the 80% of theoretical capacity in March, August, November

Figure 2 Resources used by processes

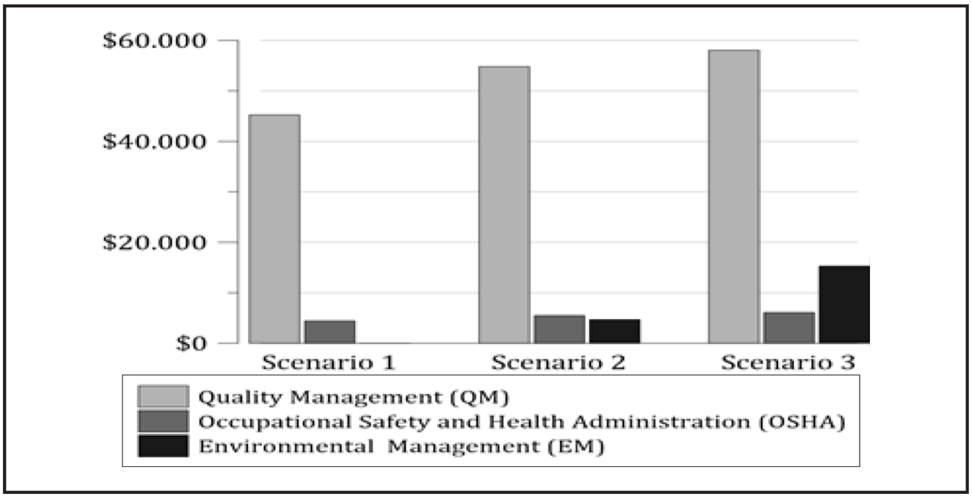
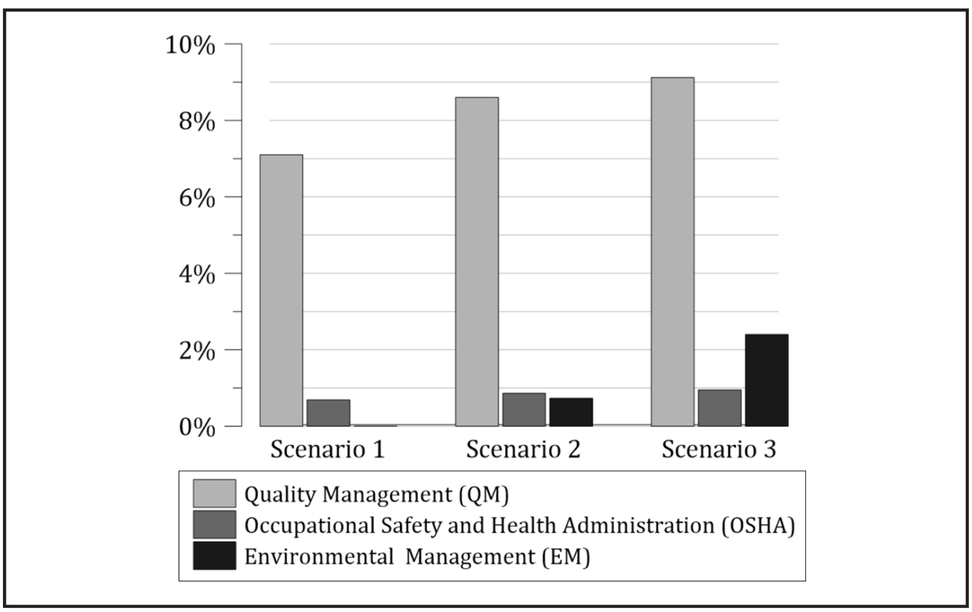


Table 5 Resources used by processes per scenario

		Analysis of the resources used by processes		
			CSR	
Costing scenario	*Level*	*Quality management (QM)*	*Occupational safety and health (OSHA)*	*Environmental management (EM)*
Scenario 3	III	US$58,222.81	US$6,097.85	US$15,287.19
Scenario 2	II	US$54,972.63	US$5,496.86	US$4,680.96
Scenario 1	I	US$45,251.75	US$4,420.48	US$12.92

Figure 3 Percentages of increase in used resources compared to the resources used in production processes



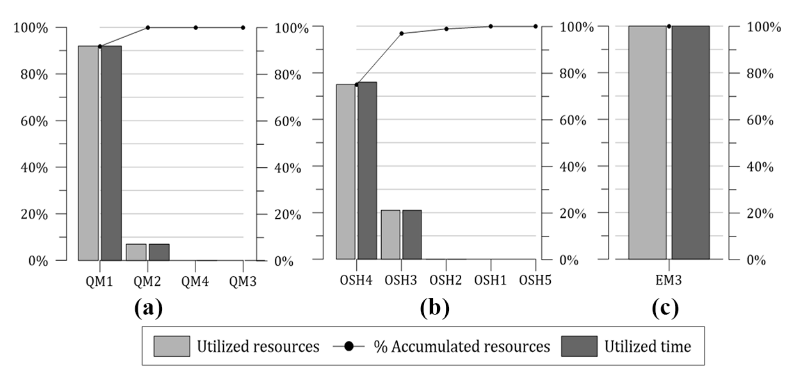
and December for Scenarios 2 and 3 in Step 3 of the TDABC calculation methodology. Thus, the practical capacity reaches a maximum of 83.5% (Appendix 4). In Scenario 1, no adjustments to practical capacity were necessary. In no case, this practical capacity exceeds the theoretical capacity. The percentages of the changes could be easily absorbed with the minimum reduction of nonproductive times for meetings and other interruptions of the production process.

TDABC allowed understanding the dynamics of business processes. Therefore, the resources and time used by seven sub-processes and 27 activities of the QM process, eight sub-processes and 37 activities of the OSHA process and six sub-processes and 21 activities of the EM process were determined in three costing scenarios. For QM processes in Scenario 1, the Pareto diagram in Figure 4(a) shows that the most representative sub-process is the quality control of finished products (QM1), which consumes 92% of the time used. Regarding the OSHA process in Figure 4(b), the Verification of OSH4 is the sub-process that consumes the most resources and time (75% and 76%, respectively). Notably, in the EM process, the sub-process environmental administration (EM3) reaches 100% of the resources and time, as shown in Figure 4(c).

In Scenario 2, the sub-process quality control of finished goods (QM1) uses 76% [Figure 5(a)]. For OSHA processes, the sub-processes verification of OSH (OSH4) and implementation of OSH (OSH3) are the most representative, with 61% and 17%, respectively, given that they consume 78% of the time [Figure 5(b)]. This situation is also repeated in Scenario 3, reaching 55% and 24%, respectively, in resource use [Figure 6(b)]. Regarding the EM process, the sub-process waste measurement (EM1) uses most resources assigned in Scenario 2, which is 70% and of the time, 49% [Figure 5(c)]. While in Scenario 3, the three sub-processes that consume 80% of the resources are the following: Carrying out the environmental audit (EM6), environmental administration (EM3) and waste measurement (EM1), with 30%, 29% and 21%, respectively. Also, these sub-processes consume 82% of the time [Figure 6(b)]. Finally, referring to QM, QM1 is again the sub-process that consumes the most resources with 72%.

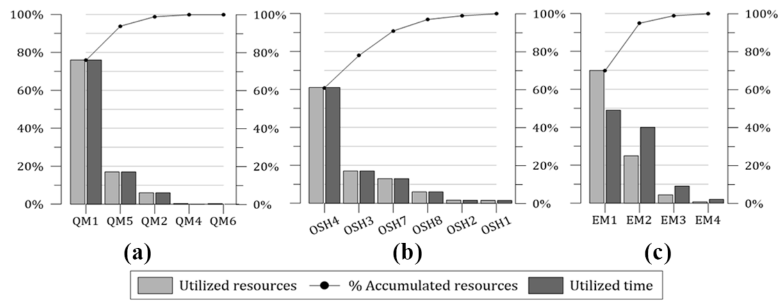
At the level of activities in Scenario 1, 80% of the used resources in the QM process corresponds to two activities: “Test functions and specifications” (AQM1) and “Product check out” (AQM2), with 55% and 27%, respectively; and thus, 82% of the processing time (Appendix 5a). For the OSHA process, “Manage OSH inspection and its documentation” (AOSH25), “Record the reports of reactive-proactive indices on the government platform”

Figure 4 Resources and time used by sub-processes in Scenario 1. a) QM process. b) OSHA process. c) EM process



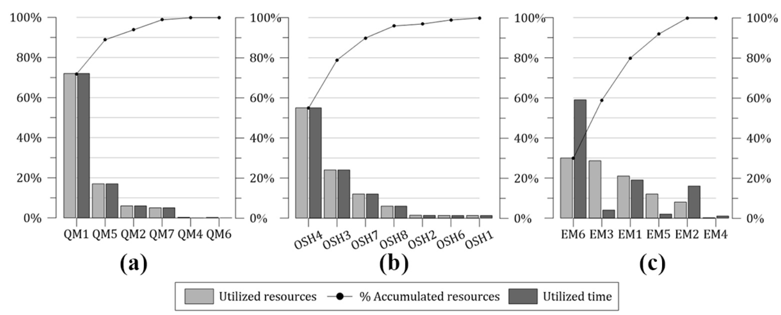
Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

Figure 5 Resources and time used by sub-processes in Scenario 2. a) QM process. b) OSHA process. c) EM process



Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

Figure 6 Resources and time used by sub-processes in Scenario 3. a) QM process. b) OSHA process. c) EM process



Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

(AOSH24) and "Renew the hygiene and safety regulations at work" (AOSH14) are the most usual activities, with 63%, 12% and 5%, respectively; together spend 80% of the time used (Appendix 5b). Finally, in the EM process, 100% of the resources and the consumed time correspond to the single activity "Preparation and/or Review of the Environmental record" (AEM8), as shown in Appendix 5c.

In Scenario 2, three activities were identified that add up to 80% of the resources used in the QM process: "Test functions and specifications" (AQM1), "Product check out" (AQM2) and "Review and adjust equipment before assembly" (AQM7), with 45%, 22 and 12%, respectively (Appendix 6a). In the OSHA process, four activities consume most of the resources: "Manage the OSH inspection and its documentation" (AOSH25), "Schedule internal audits" (AOSH36), "Record the reports of reactive-proactive indices on the government platform" (AOSH24) and "Carry out an analysis of indicators to determine possible improvements in all areas of the management system" (AOSH37), with 50%, 13%, 9% and 6%, respectively. In addition, these activities consume 51%, 13%, 6% and 4% of the time during their execution, respectively (Appendix 6b). In the EM process, the predominance of the activity move the recyclable material from the assembly area to the storage area (EM1) in resource consumption is evident with 60%, as shown in Appendix 6c. Together with "Locate recycled materials in the specified place within the assembly area" (AEM7) and "Solid waste recycling from the packaging of the raw material" (AEM5), this activity uses 80% of resources and 74% of the time.

In Scenario 3, the trend of the most usual activities within the QM process is maintained for the same activities as in Scenario 2, i.e. AQM1, AQM2 and AQM7; they consume 43%, 21% and 11% of the used resources, respectively, and 74% of the total time of this process (Appendix 7a). Within the OSHM process, 80% of the resources used correspond to five activities: "Managing OSH inspection and its documentation" (AOSH25) as the most expensive by using 45% of resources and 42% of the time shown in Appendix 7b. Finally, in the EM process, five activities consume 80% of resources and 62% of the time, where the activity "Plastic waste measurement" (AEM2) is the highest, as shown in Appendix 7c.

Finally, the findings show that TDABC can be used to determine the costs of production processes, as stated by Vedernikova *et al.* (2020) and integrate operational processes of the CSR dimensions with QM aspects. The contribution analysis of the QM, EM and OSHA processes within the total resources used can be extended through this methodology. Thus, TDABC can foster and support CSR implementation in the organization, simulate the cost consequences and assess the impact of incorporating QM and CSR dimensions. The proposed methodological framework with various TDABC scenarios can also be applied in organizations to determine which sub-processes and activities are the most expensive and decide the degree of implementation according to the needs and available resources.

5. Conclusions

The present study shows the integration of CSR and QM into the processes of a TV assembly company through TDABC. A new methodological framework was developed with four QM and CSR implementation levels from a theoretical implication. In addition, several TDABC costing scenarios were built based on the activities of important referents in each subject, such as ISO 26000, Ethos Institute, ISO 45001, ISO 9001, ISO 9004, ISO 14001, ANSI ESD S20.20 regulation, the legal requirements of Ecuador and TV brand specifications for assembly. Therefore, this document contributes to the increasing literature over new efforts to show relevant tools for decision-making on integrating QM and CSR dimensions in an accurate costing system. Finally, the proposed methodological framework was applied in a real case study in the assembly industry to simulate and assess QM and CSR operational processes from a practical implication. The resources and time used by the QM, OSHA and EM processes were determined for three scenarios in the assembly industry. The last two processes (OSHA and EM) were considered part of CSR. This work also provides significant implications to formulate time equations for each aspect studied. Findings indicate that TDABC allows knowing where and how resources are consumed within the analyzed processes. The study also highlights that TDABC can support CSR implementation in organizations, simulate the cost consequences and understand the impact of incorporating QM and CSR dimensions. Consequently, this study helps managers decide the degree of QM and CSR implementation based on their needs and availability of resources.

For the current case study, results indicate that significant investments are not always necessary to be socially responsible and manage the quality of its products. In Scenario 1, only the 8% increase was recorded in the resources used considering the QM, EM and OSHA processes, compared to the resources used in the current production processes. In Scenarios 2 and 3, these resources have increased 2% more per level, reaching 10% and 12% in total, respectively.

The steps applied in the present costing system are flexible to be implemented in other similar companies or to be extended to another. First, however, a specific identification must be made for the data collection. In this sense, particular elements of the company should be the inputs for the construction of the time equations and the corresponding costing system, such as specific processes, sub-processes and activities data, times per activity, resources and annual or monthly frequencies per activity.

As a recommendation for future research, it is proposed to analyze and integrate other CSR processes that belong to the following dimensions: ethical responsibility, philanthropic responsibility, economic responsibility. Also, including the concept of sustainable development of companies may be considered, where TDABC can be one of the tools in its assessment. Furthermore, it is suggested to include a further level of analysis that incorporates government incentives for environmental and social actions. Additionally, the developed methodological framework with TDABC costing scenarios may be applied in other organizations to measure CSR and QM implementation, such as in financial or medical sectors.

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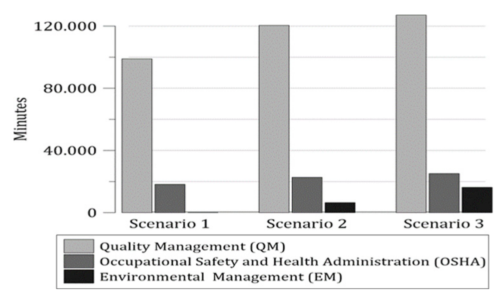
Appendix 1. List of processes, sub-processes and activities

Analyzed processes	*Sub-processes*	*Activities*
Quality management (QM)	Finished product quality control QM1	AQM1. . .AQM3
	Batch quality control QM2	AQM4
	New model quality control QM3	AQM5
	Pre-assembly training for the new model QM4	AQM6
	Preventive Maintenance QM5	AQM7. . .AQM18
	Performing external maintenance QM6	AQM19. . .AQM22
	ESD control QM7	AQM23. . .AQM27
Occupational safety and health administration (OSHA)	Training of occupational health and safety OSH1	AOSH1. . . AOSH6
	Planning of occupational health and safety OSH2	AOSH7. . . AOSH11
	Implementation of occupational health and safety OSH3	AOSH12. . . AOSH23
	Verification of occupational health and safety OSH4	AOSH24. . . AOSH27
	Accident management OSH5	AOSH28. . . AOSH32
	Management of occupational health and safety OSH6	AOSH33. . . AOSH34
	Control of OSHA process OSH7	AOSH35. . . AOSH36
	Improvement of OSHA process OSH8	AOSH37
Environmental management (EM)	Waste measurement EM1	AEM1. . . AEM4
	Solid waste management EM2	AEM5. . . AEM7
	Environmental Administration EM3	AEM8. . . AEM12
	Environmental Training EM4	AEM13. . . AEM14
	External and internal communication of results EM5	AEM15. . . AEM18
	Carrying out the environmental audit EM6	AEM19. . . AEM21

Appendix 2. Time in minutes used by processes



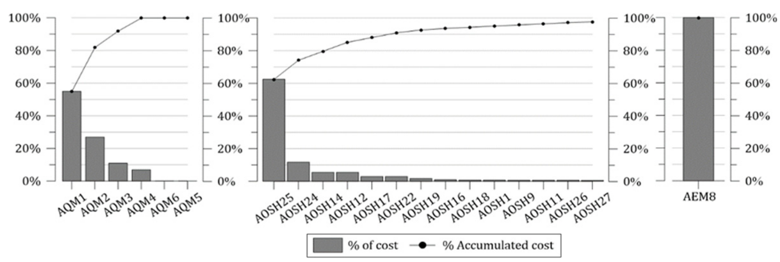
Appendix 3. Time used by processes per scenario

		Analysis of the time (minutes) used by processes			
Costing scenario	*Level*	*Quality management (QM)*	*Occupational safety and health (OSHA)*	*Environmental management (EM)*	*Dimensions*
SCENARIO 3	III	127.412,56	25.183,33	16.319,50	QM
SCENARIO 2	II	120.717,68	22.700,00	6.439,83	CSR
SCENARIO 1	I	98.933,43	18.225,00	51,67	

Appendix 4. Adjustments in the practical capacity

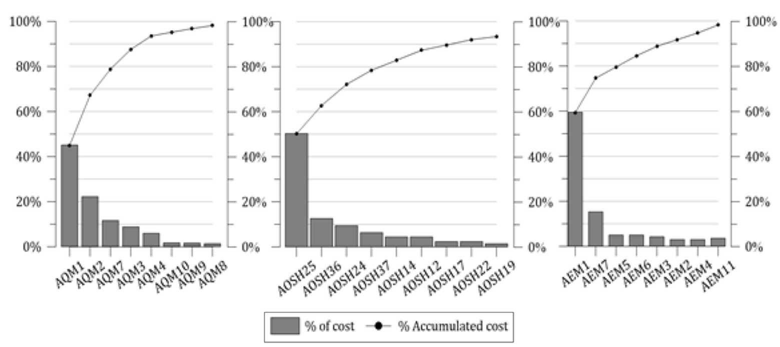
Senario	*Process*	*Month*	*% Adjustments*
Senario 3	TV Warehouse	March	0,20
	TV Assembly	March	0,80
	TV Assembly	August	3,50
	TV Assembly	November	2,10
	TV Assembly	December	2,10
Senario 2	TV Warehouse	March	0,20
	TV Assembly	August	2,60
	TV Warehouse	November	1,50
	TV Assembly	December	1,50

Appendix 5. Resources used by activities in scenario 1. a) QM process. b) OSHA process. c) EM process



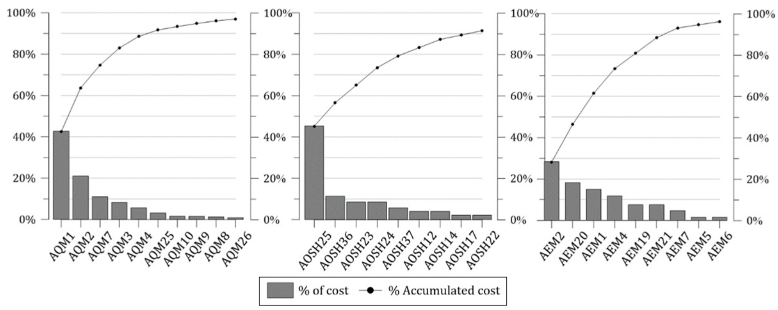
Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

Appendix 6. Resources used by activities in scenario 2. a) QM process. b) OSHA process. c) EM process



Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

Appendix 7. Resources used by activities in scenario 3. a) QM process. b) OSHA process. c) EM process



Notes: * QM = Quality Management
** OSHA = Occupational Safety and Health Administration
*** EM = Environmental Management

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