Impact of Workload Balancing on the Sustainability of Processes in a Manufacturing Company

Arturo Realyvásquez-Vargas, Perla María Larrañaga, Karina Cecilia Arredondo-Soto, Guadalupe Hernández-Escobedo, Amalia Carmina Salinas-Hernández
Department of Industrial Engineering
Tecnológico Nacional de México/Instituto Tecnológico de Tijuana
Tijuana, Baja California, Mexico
arturo.realyvazquez@tectijuana.edu.mx, perla.larranagam201@tectijuana.edu.mx, karina.arredondo@tectijuana.edu.mx, guadalupe.hernandez@tectijuana.edu.mx, asalinas@tectijuana.edu.mx

Abstract

Nowadays, manufacturing companies are looking to improve their sustainability in the market. However, there are several factors that negatively affect it, such as workload imbalance among workers, defective parts, and customer complaints, to name a few. This paper presents a case study of a workload imbalance in a global customer complaint follow-up process in a manufacturing company, generating lagged complaints (no follow-up), which has negatively impacted the sustainability of the process. Due to this, the objective of this project is to increase the sustainability of the process by reducing the number of delayed complaints. To do this, the causes of the problem are identified. Then, an analysis of the process flow map is performed to see the current distribution of the workload among the different plants of the company. Moreover, corrective actions are implemented and followed up. Subsequently, the process is standardized, transferred by parts to the different plants, monitored for control, and the effectiveness of the actions is measured. As a result, there was an increasing trend in terms of compliance in the capture of complaints, starting with 84% and reaching 97%. Similarly, the total number of complaints received showed a decreasing trend. Finally, zero delayed/indefinite complaints (no follow-up) were obtained. Therefore, it is concluded that workload balancing has a positive impact on the sustainability of processes in manufacturing companies.

Keywords
Global process for tracking complaints, customer complaints, delayed complaints, and sustainability.

1. Introduction
Sustainability is divided into three dimensions: economic, social, and environmental (Fischer, Brettel, & Mauer, 2020). This research focuses only on economic sustainability, which is defined as the ability to efficiently use available resources to ensure profitability over time (Barile, Quattrociocchi, Calabrese, & Iandolo, 2018). One of the sectors contributing most to economic expansion is the manufacturing industry (Olufayo, 2019). However, even today, companies face problems that negatively impact their sustainability, such as defects in their products (Goyal, Agrawal, & Saha, 2019), customer complaints (Neves et al., 2018), low sales, or low productivity (Fatimah & Aman, 2018), to mention few. In addition, the human factor plays a key role in the sustainability of companies (Mercado-Burciaga, 2020). Therefore, it is required that there is a balance of the workload among workers and that the workload is not classified as high so that they can perform their tasks adequately (Fathi, Nourmohammadi, Ghobakhloo, & Yousefi, 2020; Miranda, Indrawati, & Wulandari, 2018). As a result, manufacturing companies must implement strategies to make efficient use of resources (Kishawy, Hegab, & Saad, 2018), and thus maintain a good level of sustainability. Although studies have been conducted to assess sustainability in the manufacturing sector, most of them have focused on assessing the sustainability of the manufactured product, while efforts to assess sustainability at the process level are relatively limited, focusing mainly on specific processes such as turning, milling or grinding (Saad, Nazzal, & Darras, 2019).

For instance, Ngai, Chau, Poon, and To (2013) developed an energy and utility maturity framework for systematic measurement and management of natural resource consumption for sustainable manufacturing process. Similarly, Jayal, Badurdeen, Dillon, and Jawahir, (2010) presented an overview of recent trends and new concepts in the

development of sustainable products, processes and systems. In particular, these authors presented recent trends in developing improved sustainability scoring methods for products and processes, and predictive models and optimization techniques for sustainable manufacturing processes, focusing on dry, near-dry and cryogenic machining. Therefore, a case study of a global customer complaint tracking process is presented in this research. The research is conducted in a manufacturing company dedicated to the development and manufacture of medical technology that seeks to improve medical discoveries, diagnostic systems, and health services. The company has five plants, which will be called plant 1, plant 2, plant 3, plant 4, and plant 5. Each plant is made up of the areas of Management, Quality Systems, Supplier Quality, Manufacturing, Human Resources, Accounting, Engineering, Health and Safety, Warehouse and Continuous Improvement. The investigation is carried out in the Quality Systems area, since it is in charge of receiving, capturing and processing customer complaints, sending samples of nonconforming product, investigating the customer complaint and taking corrective actions to resolve the reported problem and provide a timely response to the customer.

Figure 1 shows the overall complaint follow-up process for reporting late complaints, i.e., those that have not been followed up and, therefore, clients have not received a response. As can be seen, the process starts with the customer reporting the complaint. Plant 1 then receives the complaint and captures it in the system, in addition to receiving samples of the reported part number. Plant 2 then escalates the complaint for follow-up at the responsible manufacturing plant (Plant 3, 4 or 5) to detect the root cause of the complaint and propose corrective actions. Once the complaint investigation is completed, the complaint is sent to plant 1, where the information is captured, and the end customer is notified of the complaint resolution (Figure 1a). Figure 1b shows the workload distribution. Note that plant 1 performs four activities (blue boxes), plant 2 only performs one activity (red box), while the on-site customer complaint follow-up activity is distributed among plants 3, 4 and 5, according to the responsibility of each of them.

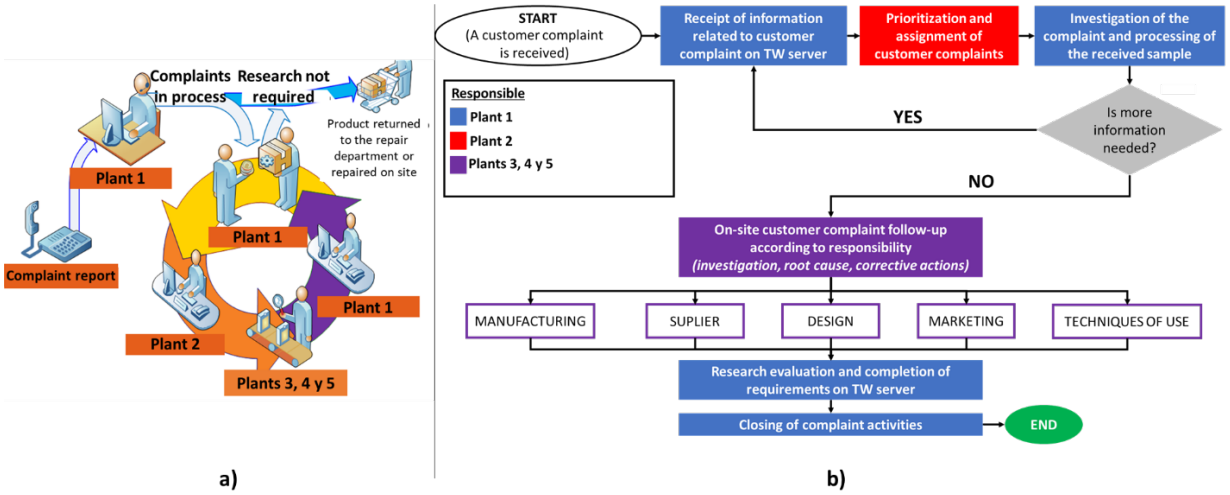

Figure 1. a) Global complaint follow-up process, b) Workload distribution between plants.

In this process there are some weaknesses, among them is the unbalance of the workload between plants, being plant 1 the one with a high workload. This results in the late receipt and incorrect capture of customer complaints. This prevents an effective follow-up of the complaint process, prevents timely response to the customer, and leads to customer dissatisfaction. Recently, the company has received 423 undefined complaints from its customers, which have been left behind without a follow-up and, therefore, without a response to the customers, negatively affecting the sustainability of the process.

Therefore, the general objective of this research is to increase the sustainability of the global customer complaint follow-up process. The specific objectives are to transfer the process of receiving and capturing customer complaints from plant 1 to plants 2, 3 and 4, and to balance the workload in the plants.

Based on the above, the following assumptions are made:

- Assumption 1 (A1): Training workers on the global complaint tracking process has a direct and positive impact on the transfer of the global complaint tracking process.
- Assumption 2 (A2): Standardization of the global customer complaint tracking process has a direct and positive impact on the transfer of this process to other plants.
- Assumption 3 (A3): The transfer of the global complaint tracking process has a direct and positive impact on workload balancing.
- Assumption 4 (A4): Workload balancing has a direct and positive impact on decreasing lagged (untracked) complaints.
- Assumption 5 (A5): Decreasing of lagged (untracked) complaints has an indirect and positive impact on the sustainability of the global complaint tracking process.

Figure 2 shows the causal model with the five assumptions.

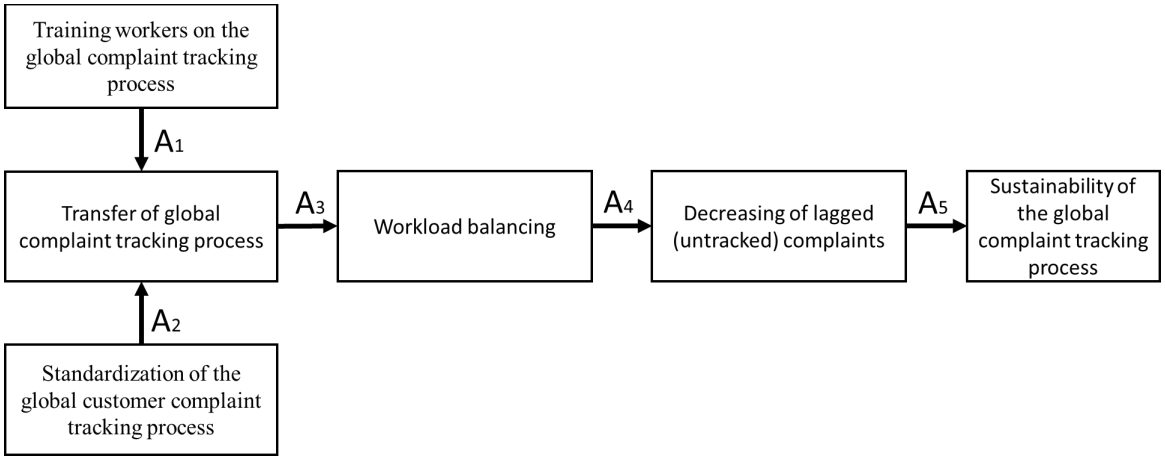

Figure 2. Causal Model

2. Methodology

To implement the methodology of this project, equipment and tools such as microscopes, vernier, megohmmeter, syringes, infusion equipment, are used to adapt a laboratory in plant 3. Figure 3 shows the method applied to achieve the objectives mentioned above.

The following is a detailed description of how each stage of the method is carried out.

2.1 Stage 1: Identification of causes of overdue complaints

To identify the causes of lagging complaints, an Ishikawa diagram is developed (Wong, 2011; Wong, Woo, & Woo, 2016). In this, the problem to be solved is written and aspects related to labor, machinery, measurement, method, materials and environment are taken into account as possible causes. Subsequently, a root cause analysis is performed by applying the Vester matrix to confirm the causes found (Puentes-Montañez, 2011). Next, we proceed to find influences among the same causes, using the following criteria:

- 0 = Does not cause it,
- 1 = It causes it indirectly or has a very weak causal relationship,
- 2 = It causes it in a semi-direct way or has a medium causal relationship,
- 3 = Causes it directly or has a strong causal relationship.

Once these influences and dependencies have been summed up, they are plotted according to their motricity to define which problems are critical, i.e., which problems must be solved.

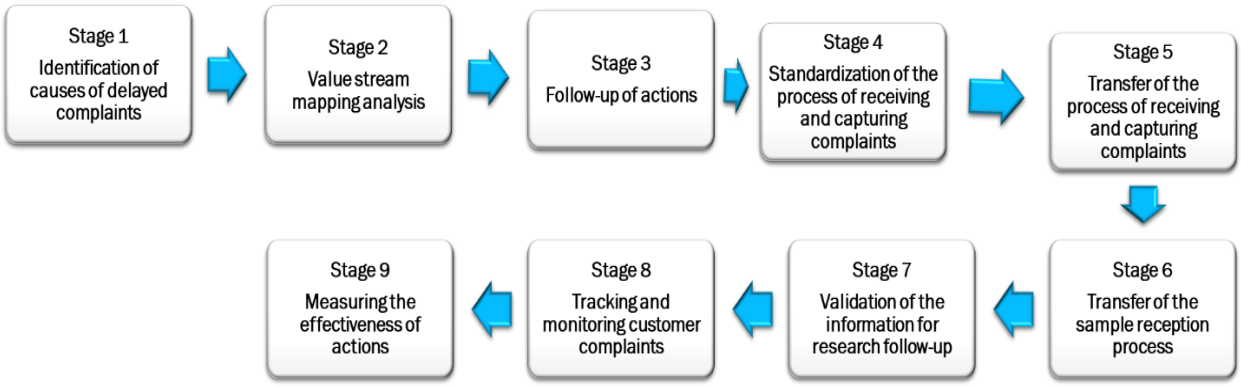

Figure 3. Method for the transfer of the global grievance tracking process

2.2 Stage 2: Value stream mapping analysis

In this stage, all the details and activities of the process and its relationship with customer complaint sub-processes are analyzed to visualize the current status of the process in terms of the workload of each plant, as well as to define the expected process (Singh, Garg, & Sharma, 2011). To carry out this stage, an engineer with knowledge in the value stream is hired to carry out the activity.

2.3 Stage 3: Follow-up of actions

To follow up on the actions necessary for the transition of the customer complaint process, weekly meetings are held every Tuesday and Thursday from June 6 to December 31, 2020, with the different plants. These meetings are scheduled to review the status of the actions to achieve the transfer of the process from plant 1 to other plants (plant 2, 3, 4 and/or 5).

2.4 Stage 4: Standardization of the process for receiving and capturing complaints

At this stage, the process of receiving and capturing complaints is standardized. This is so that it can be transferred in parts to the other plants. To this end, reference procedures are created and defined for the other plants, describing the steps to be followed to carry out the capture process and their different responsibilities.

2.5 Stage 5: Transfer of the process of receiving and capturing complaints

In this stage, the process of capturing complaints from plant 1 is transferred to the other plants. For this purpose, the employees of these plants are trained on the activities of the process. For this stage, the updated TW® 2020 system must be acquired to capture complaints.

2.6 Stage 6: Transfer of the sample reception process

In order to transfer the process of receiving complaint samples, the workers at each plant are trained on the new activities to be performed. At this stage, equipment and tools are acquired to adapt the laboratory for sample handling (microscopes, verniers, megohmmeters, syringes, infusion equipment).

2.7 Stage 7: Validation of the information for research follow-up

Here we verify that the information reported in customer complaints by the new responsible plant is complete in order to redirect the investigation to the manufacturing team in charge of it. Plant 1 makes a day-by-day summary of the complaints reported in the TW® system and, at the end of the month, makes a comparison of the complaints with missing information. In addition, the percentage of compliance of the other plants is reviewed.

2.8 Stage 8: Follow-up and monitoring of customer complaints

To track and monitor reported complaints for investigation, Key Performance Indicators (KPIs) are used, such as incoming customer complaint metrics, information needed vs. customer complaint information, and reported vs. closed complaints with follow-up. Metrics are ideal for tracking and monitoring customer complaints.

2.9 Step 9: Measurement of action effectiveness

To measure the effectiveness of the actions, we check whether the process transferred from plant 1 to the other plants is effective. In addition, it is verified that customer complaints are being followed up in a timely manner and that none are lagging behind. A customer complaint monitoring KPI is used to measure the transition of the process (metric of complaints reported vs. complaints closed with follow-up).

3. Results

This section presents the results obtained by applying the methodology described above. Figure 4 shows an Ishikawa diagram with the different causes detected for the problem of complaints without follow-up. As can be seen, with respect to labor, the following causes were detected:

- Lack of personnel in the process.
- Customer complaints with lack of information in the system (ineffective complaint capture).
- Receipt of complaints reported as not effective, since not all complaints are processed in a timely manner.

On the other hand, the following causes were detected within the method:

- Current process approach not perfectly understood at all levels.
- Global customer complaint process method with opportunity for improvement and standardization.
- Method not robust at global level.

Finally, in the area of measurement, it was detected that there is an incorrect measurement of the information needed to receive complaints. All these causes have a direct impact on the overall complaint follow-up process. Table 1 shows the Vester matrix with the relationships of the different causes, while Figure 5 shows the causes that were most critical for the problem of complaints without follow-up (delayed).

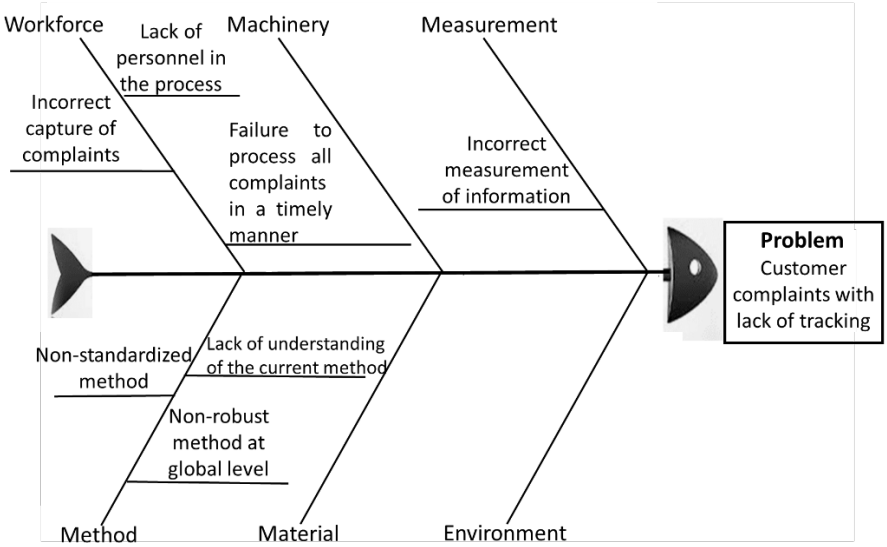

Figure 4. Ishikawa diagram for causes of complaints without follow up.

Table 1. Vester matrix of causes

Representation	Cause	P1	P2	P3	P4	P5	P6	P7	X-axis
P1	Failure to process all complaints in a timely manner	0	0	3	3	3	3	3	15
P2	Incorrect capture of complaints	0	0	2	3	3	3	2	13
P3	Lack of personnel in the process	2	3	0	0	0	0	0	5

P4	Incorrect measurement of information	2	3	0	0	3	2	2	12
P5	Lack of understanding of the current method	3	3	0	3	0	3	0	12
P6	Non-standardized method	3	3	0	1	3	0	2	12
P7	No robust method	1	2	0	1	3	3	0	10
Y-axis (Dependency)		11	14	5	11	14	15	9	158

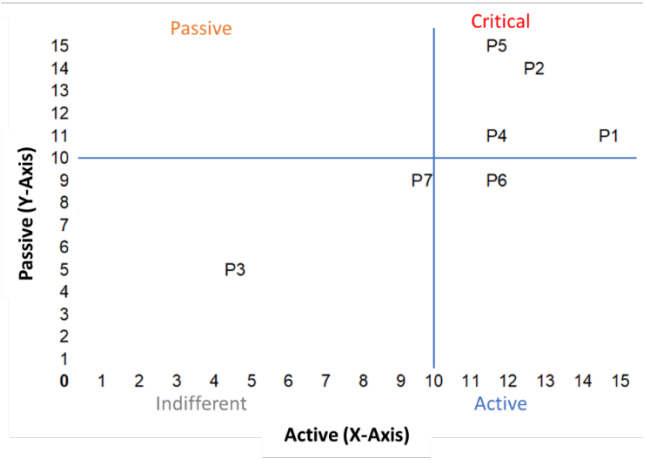

Figure 5. Determination of the critical causes of the problem of complaints without follow-up

As can be seen, the most critical causes were the following:

- Not all complaints are processed in a timely manner (P1).
- Lack of understanding of the current method (P5).
- Incorrect capture of complaints (P2).
- Incorrect measurement of information (P4).
- Non-standardized method (P6).

The training given to workers in plants 2 and 3 focused on eliminating these causes. On the other hand, Figure 6 shows the new workload distribution, which is more balanced between plants 2, 3 and 4, in comparison with the load distribution shown in Figure 1.b.

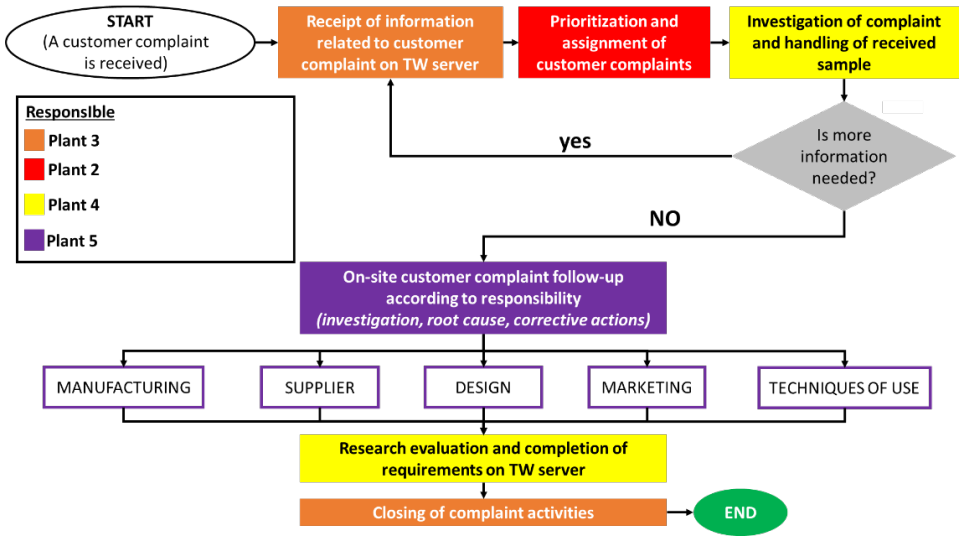

Figure 6. Distribution of the workload between plants after the project has been carried out

Figure 7 shows the results according to the compliance obtained in the effective capture of customer complaints in the period September - December 2020. As can be seen, there was an increasing trend in terms of compliance in the capture of complaints, starting with 84% and reaching 97%. Similarly, the total number of complaints received showed a decreasing trend.

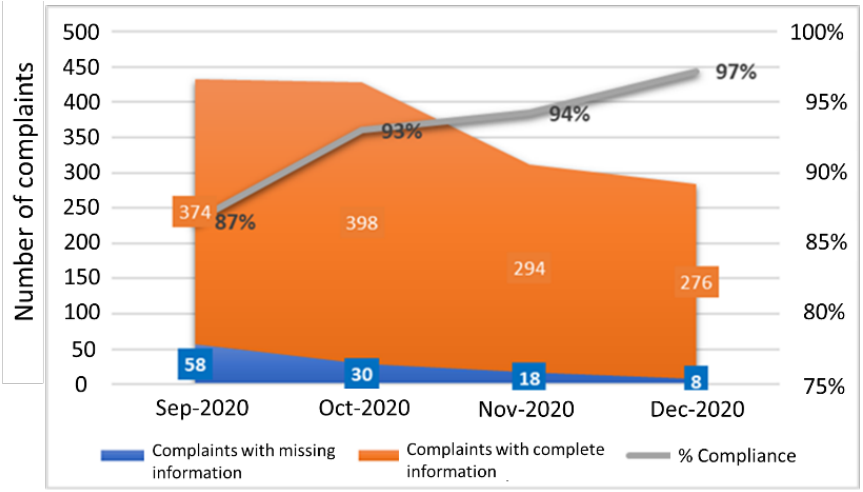

Figure 7. Percentage of compliance in the capture of customer complaints

Figure 8 shows the results regarding the completeness of the information for the investigation of complaints in the period from December 2020 to April 2021. As can be seen, only in the month of December 2020 was one complaint left unreported, but in the months of January to April 2021 all complaints were reported, as the information needed for the investigation was complete and on time, so no complaint was left without follow-up in the months of 2021.

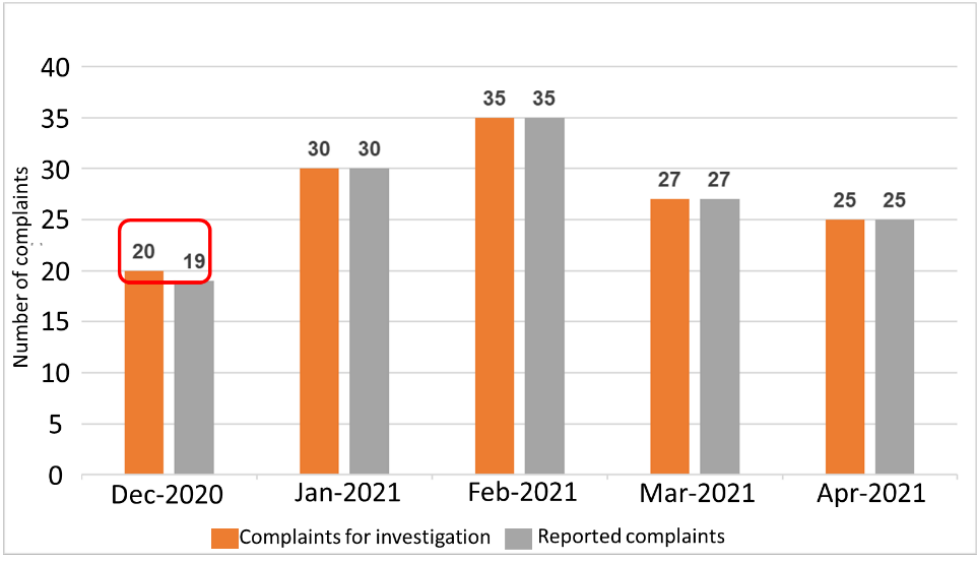

Figure 8. Comparison of complaints for investigation and reported complaints

The review of the transferred process showed that it was effective, since it was possible to follow up on customer complaints in a timely manner, resulting in zero delayed/indefinite complaints (no follow-up) in the period from January to April 2021, as can be seen in Figure 9.

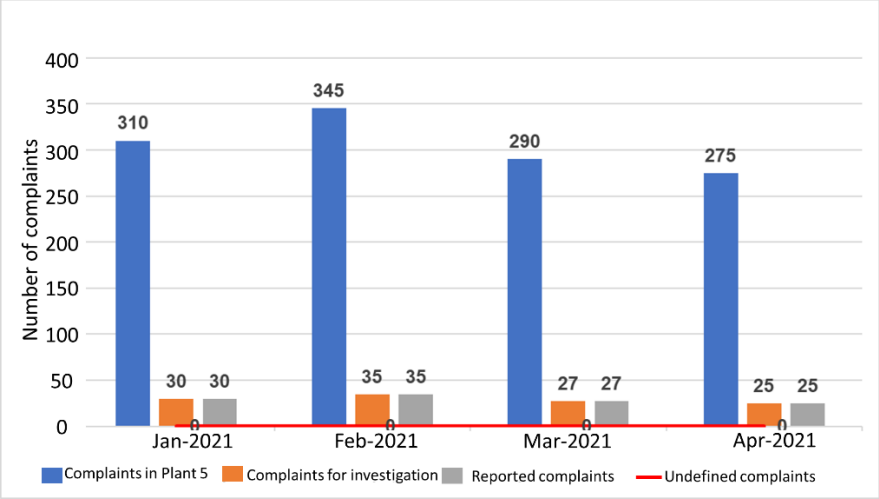

Figure 9. Number of undefined complaints in the period January-April 2021[1]

4. Conclusions

According to the results obtained, which indicated that only in the month of December there was only one customer complaint without follow-up and that in the following four months the result was zero delayed/indefinite complaints (without follow-up), it can be concluded that the general objective of this project, which was to increase the sustainability of the process, was met.

As remember, the specific objectives were the following:

- Transfer the process of receiving and capturing customer complaints from plant 1 to the other plants.
- Balance the workload in plants.

Regarding them, it is concluded that this was achieved, since the process was transferred from plant 1 to plants 3 and 4, thus balancing the workload between plants (see Figure 5).

With respect to the assumptions, the following is concluded:

- Assumption 1 (A1): Training workers on the global grievance follow-up process has a direct and positive impact on the transfer of the global grievance follow-up process. It is concluded that there is insufficient evidence to reject this assumption, since training workers on the new process and their understanding of it was a key element for them to perform it effectively.
- Assumption 2 (A2): Standardization of the global customer complaint follow-up process has a direct and positive impact on the transfer of this to other plants. It is concluded that there is insufficient evidence to reject this assumption, since the standardization of the process was a key element for it to be carried out effectively.
- Assumption 3 (A3): The transfer of the global customer complaint follow-up process has a direct and positive impact on workload balancing. As in the previous cases, it is concluded that there is insufficient evidence to reject this assumption, since the transfer of allowed workers from different plants to have a more balanced workload among them.
- Assumption 4 (A4): Workload balancing has a direct and positive impact on the decrease of lagged complaints (no follow-up). The results indicate that there is insufficient evidence to reject this assumption, since workload balancing allowed the number of lagged complaints to decrease.
- Assumption 5 (A5): The decrease in lagged complaints (without follow-up) has a direct and positive impact on the sustainability of the overall complaint follow-up process. Finally, we conclude that there is insufficient

[1] The blue bar reflects the complaints reported month after month, of which can be manufacturing, design, supplier or marketing responsibility and clinical recommendations (user errors when using the product), the orange bar are the complaints to investigate only manufacturing responsibility, so for example in the month of January of the 310 complaints there were only 30 were manufacturing responsibility.

evidence to reject this assumption, since, as the results indicated, the number of delayed client complaints decreased, and therefore, the sustainability of the process increased (Goyal et al., 2019).

As mentioned in the Introduction section, customer complaints have a direct impact on the sustainability of companies. Based on this background and the results obtained, the contribution of this project is to establish that workload balancing through process transfer has a direct impact on the number of customer complaints in the first instance, and on the sustainability of companies in the second instance. Therefore, workload balancing allows companies to use their resources efficiently.

Finally, it is concluded that the standardization of a process and the training of workers on this process have an impact on the reduction of customer complaints and, therefore, on the sustainability of the process and of the company.

4.1 Limitations

The limitations of this project were the time available, since the necessary resources, both human and material, were allocated for the project. However, although the results of the project were as expected according to what was planned in the general and specific objectives, if more time had been allocated to each stage of this research project, perhaps the results would have been more precise and more favorable.

4.2 Recommendations

As future work, it is recommended that the company review other processes and the distribution of the workload among employees in order to improve its level of sustainability. In addition, it is also recommended to convert the variables of the causal model into latent variables, and the assumptions into hypotheses to perform a statistical analysis in a sample of more companies and more processes.

References

Barile, S., Quattrociocchi, B., Calabrese, M., & Iandolo, F. Sustainability and the Viable Systems Approach: Opportunities and Issues for the Governance of the Territory. *Sustainability*, *10*(3), 790. https://doi.org/10.3390/su10030790, 2018.

Fathi, M., Nourmohammadi, A., Ghobakhloo, M., & Yousefi, M. Production Sustainability via Supermarket Location Optimization in Assembly Lines. *Sustainability*, *12*(11), 4728. https://doi.org/10.3390/SU12114728, 2020.

Fatimah, Y. A., & Aman, M. Remanufacturing sustainability indicators: An Indonesian small and medium enterprise case study. *IOP Conference Series: Materials Science and Engineering*, *403*(1), 012055. https://doi.org/10.1088/1757-899X/403/1/012055, 2018.

Fischer, D., Brettel, M., & Mauer, R. The Three Dimensions of Sustainability: A Delicate Balancing Act for Entrepreneurs Made More Complex by Stakeholder Expectations. *Journal of Business Ethics*, *163*(1), 87–106. https://doi.org/10.1007/S10551-018-4012-1, 2020.

Goyal, A., Agrawal, R., & Saha, C. R.. Quality management for sustainable manufacturing: Moving from number to impact of defects. *Journal of Cleaner Production*, *241*, 118348. https://doi.org/10.1016/J.JCLEPRO.2019.118348, 2019.

Jayal, A. D., Badurdeen, F., Dillon, O. W., & Jawahir, I. S. Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*, *2*(3), 144–152. https://doi.org/10.1016/J.CIRPJ.2010.03.006, 2010.

Kishawy, H. A., Hegab, H., & Saad, E. Design for Sustainable Manufacturing: Approach, Implementation, and Assessment. *Sustainability*, *10*(10), 3604. https://doi.org/10.3390/SU10103604, 2018.

Mercado-Burciaga, U. Sustainability Assessment in Housing Building Organizations for the Design of Strategies against Climate Change. *HighTech and Innovation Journal*, *1*(4), 136–147. https://doi.org/10.28991/HIJ-2020-01-04-01, 2020.

Miranda, S., Indrawati, S., & Wulandari, W. Analysis of Mental Workload in Human Resource Department. In *Proceedings - 2018 4th International Conference on Science and Technology, ICST 2018* (pp. 1–5). Yogyakarta, Indonesia : Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICSTC.2018.8528658, 2018.

Neves, P., Silva, F. J. G., Ferreira, L. P., Pereira, T., Gouveia, A., & Pimentel, C. Implementing Lean Tools in the Manufacturing Process of Trimmings Products. *Procedia Manufacturing*, *17*, 696–704. https://doi.org/10.1016/J.PROMFG.2018.10.119, 2018.

Ngai, E. W. T., Chau, D. C. K., Poon, J. K. L., & To, C. K. M. Energy and utility management maturity model for sustainable manufacturing process. *International Journal of Production Economics*, *146*(2), 453–464. https://doi.org/10.1016/J.IJPE.2012.12.018, 2013.

Olufayo, M. B. The contribution of manufacturing sector to economic growth (1981-2015). In *41st International Scientific Conference on Economic and Social Development* (pp. 167–177). Belgrade, 2019.

Puentes-Montañez, G. A. *Formulación y evaluación de proyectos agropecuarios* (1st ed.). Bogotá: Ecoe Ediciones. Retrieved from https://books.google.com/books/about/Formulación_y_evaluación_de_proyectos.html?hl=es&id=KL80DgAAQBAJ, 2011.

Saad, M. H., Nazzal, M. A., & Darras, B. M. A general framework for sustainability assessment of manufacturing processes. *Ecological Indicators*, *97*, 211–224. https://doi.org/10.1016/J.ECOLIND.2018.09.062, 2019.

Singh, B., Garg, S. K., & Sharma, S. K. Value stream mapping: literature review and implications for Indian industry. *The International Journal of Advanced Manufacturing Technology*, *53*(5), 799–809. https://doi.org/10.1007/S00170-010-2860-7, 2011.

Wong, K. C. Using an Ishikawa diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature. *Journal of Medical Case Reports*, *5*(1), 1–3. https://doi.org/10.1186/1752-1947-5-120/FIGURES/1, 2011.

Wong, K. C., Woo, K. Z., & Woo, K. H. Ishikawa diagram. In W. O'Donohue & A. Maragakis (Eds.), *Quality Improvement in Behavioral Health* (pp. 119–132). Springer International Publishing. https://doi.org/10.1007/978-3-319-26209-3_9/FIGURES/7, 2016.

Biographies

Arturo Realyvásquez-Vargas is a full-time professor from the Department of Industrial Engineering at Tecnológico Nacional de Mexico/Instituto Tecnológico de Tijuana in Mexico. He received a master's degree in Industrial Engineering and a Ph.D. in Engineering Sciences from the Autonomous University of Ciudad Juarez in Mexico. Currently, he is studying for a Ph.D. in Innovation in Product Engineering and Industrial Process at the University of La Rioja (Spain). In addition, his main research areas are related to the optimization of industrial processes, lean manufacturing, and ergonomics. He is an active member of the Society of Ergonomists of Mexico Civil Association (Sociedad de Ergonomistas de México, SEMAC) and the Network of Optimization of Industrial Processes (Red de Optimización de Procesos Industriales, ROPRIN). Currently, Dr. Realyvásquez is a National Researcher recognized by the National Council of Science & Technology of Mexico (CONACYT) as level I. Furthermore, Dr. Realyvásquez is an author/co-author of around 12 papers in journals indexed in the Journal Citation Reports. He has attended international conferences and congresses in Mexico and the United States of America. Nowadays, Dr. Realyvásquez has supervised more than twenty bachelor theses and five master theses. In addition, Dr. Realyvásquez is the author of two books published by the international publisher Springer related to ergonomics. Also, Dr. Realyvásquez has edited books in IGI Global and Springer related to industrial engineering or ergonomics. ORCID: https://orcid.org/0000-0003-2825- 2595, Scopus Author ID: 56167726800.

Perla María Larrañaga is a graduate of the Master's degree in Industrial Engineering from Tecnológico Nacional de México/I.T. Tijuana. She is also a Quality Engineer - After Sales Support at Sistemas Medicos Alaris / Tijuana. This is her first publication.

Karina Cecilia Arredondo-Soto received her B.S. and master's degrees in industrial engineering from the Technological Institute of Tijuana, Mexico, in 2005 and 2010, respectively, and the Ph.D. degree in sciences of industrial engineering from the Technological Institute of Ciudad Juarez in 2017. She is currently a Professor of industrial engineering with the Chemical Sciences and Engineering Faculty, Autonomous University of Baja California. She is the Leader of the Process and Product Innovation Academic Group endorsed by the Teacher Professional Development Program (PRODEP) in Mexico. She has participated in several research projects related to process improvement. She is the author/co-author of more than 30 journal articles, books, book chapters, and conference papers. Her research interests include linkage with the productive sector to improve the indicators of the productive processes from the perspective of sustainability and human factors. She is a member of the National System of Researchers of the National Council of Science and Technology in Mexico.

Guadalupe Hernández-Escobedo has a Ph.D. in Information Behaviour and Cognitive Engineering at The University of Leeds, UK; National Researcher Candidate by CONACYT and Perfil Deseable by PRODEP; and more

than 23 years of experience in teaching, research and application of Industrial Engineering at Tecnológico Nacional de México/Instituto Tecnológico de Tijuana.

Amalia Carmina Salinas-Hernández is a professor at Tecnológico Nacional de México/I.T. Tijuana. She is an Industrial Engineer with a Master's Degree in Industrial Engineering Sciences and a Master's Degree in Education. She has extensive experience in the private manufacturing industry in the area of Quality Management; 23 years as a teacher in various local universities teaching subjects such as Statistical Quality Control, Quality Systems Management, Quality Engineering, Operations Management, Facilities Planning and Design, Work Study, Research Fundamentals, among others. She has been a member of associations such as ASQ, RIENO, SEMAC and AEII, besides having certifications in the use of Lean Manufacturing tools, certified as a Quality Engineer by ASQ, and Certified as an Internal Auditor of ISO 9001:2015 by IQS. She has been an internal auditor of ITT's quality system for more than 12 years performing roles as lead auditor. Her latest publication was Operation, Monitoring and Improvement of the Quality System Management System using ISO 9001:2015.