- 1 *Type of the Paper Case Report.*
- 2 Improving Distribution Process using Lean
- 3 Manufacturing and Simulation: A case of Mexican

4 Seafood Packer Company

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14 Featured Application: For applications in micro, small, and medium Latin-American companies.

15 Abstract: During the last decades, the production systems have developed different strategies to 16 increase their competitiveness in the global market. In a manufacturing and services systems, Lean 17 Manufacturing has been consolidated through the correct implementation of its tools. The present 18 paper presents a case study developed in a Food Packer company where a Simulation Model was 19 considered as an alternative to reduce the waste time generated by the poor distribution of 20 operations and transportation areas for a product within the factory. As a matter of fact, the 21 company has detected problems on the layout distribution that prevents to fulfill the market 22 demand. In addition, the principal aim was to create a simulation model to test different 23 hypothetical scenarios and alternative designs for the layout distribution without modifying its 24 facilities. Moreover, the implemented methodology was based on classical models of simulation 25 projects and a compendium of the manufacturing systems optimization by simulation process used 26 during the last ten years. Also, a mathematic model supported by the Promodel ® simulation 27 software was developed considering the company characteristics; along with the model 28 development, it was possible to compare the production system performance from the percentage 29 of used locations, the percentage of resources utilization, the number of finished products, and the 30 level of Work in Process (WIP). Finally, the verification and validation stages were performed 31 before running the scenarios in the real production area. The results generated by the 32 implementation of the project represent an increase of 68% in the production capacity and a 33 reduction of 5% in the WIP. In addition, both outcomes are associated with the resources 34 management, which were reassigned to other production areas.

Keywords: Production System, Simulation Manufacturing Process, Simulation Model, Work in
 Process.

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38 1. Introduction

Nowadays, globalization has detonated the necessity of improving manufacturing and service systems with the only aim of surviving in a competitive market [1]. Currently, there are many alternatives for increasing the productivity in manufacturers and service companies, most of them were developed by transnational companies with complex systems and global presence, for

43 instance, Toyota Motor company, Nokia Corporation, Bombardier Aerospace, Procter & Gamble,

44 among others [2]. In addition, the strategies from these companies have several purposes, for 45 example, Stahl [3] presents a "Leadership" analysis, under this context, the strategy is focused on the 46 appropriate employees training by develop their leader abilities. In addition, it is evident that in 47 many companies, employees are a key factor to improve their global or competitiveness level. 48 Therefore, it is clear that in this strategy the main idea is to identify the potential of the human 49 resources and give them the right preparation to develop their leaders as Toyota has been doing it 50 during the last decades [4,5].

51 Furthermore, other strategies that are not focused on human resources, are strategies that use a 52 high percentage of their capital on technological development [6], innovation [7], and in some cases, 53 the supply chain management [8]. In addition, one of the most recent strategies to manage the 54 supply chain is associated with the market expansion through exportation. For instance, 55 Padilla-Perez & Hernández [9] have described the impact of the strategies developed in Mexico to 56 increase the presence of electronic manufacturers in South-America, these strategies describe how 57 this technological upgrading has faced the Asian competition with the only advantage of company 58 localization. Also, this strategy is not only focused on logistics but also on increasing the service level 59 by reducing the distance between customer and supplier. However, the strategy is not only building 60 new facilities, it is based on creating alliances and identifying business opportunities with micro, 61 small, and middle companies that may produce the quantity and the quality demanded by the 62 customers. All these efforts are centered on reducing distances and logistics costs, in other words, 63 managing the supply chain.

As a consequence from the new age technology implementation, many companies have been adopting another type of strategies focused on increasing their productivity, reduce their costs, and optimize their resources [10]. For instance, these technologies are lean manufacturing, six sigma, automatization, additive manufacturing, new materials, among others.

68 Due to the complexity of these plans or strategies, having access to them is difficult because 69 they are (in many cases) available only for organizations that have enough capital to reach them. In 70 other cases where the companies do not have enough resources, the alternative to deploy 71 improvement actions is to develop the appropriate adaptations to complex plans, strategies or 72 methodologies, as well as to create a better plan [11]. In this way, micro, small, and medium size 73 organizations have started to adopt and implement the strategies developed by international 74 companies, making adaptations and deformations on the original strategies. Additionally, it is clear 75 that these companies want the success achieved by bigger companies. The results from the 76 integration of unique adaptations and improvements are denominated "customized strategies" 77 [12,13].

78 Moreover, being involved in dynamical changes to improve strategies, some national and 79 international companies have performed simulation as a strategy and tool to improve their capital 80 flow, money savings, as well as creating a new way to take decisions according to their developing 81 process [14]. Since simulation was available for manufacturers, it is one of the most rentable ways to 82 improve and optimize a manufacturer and service systems. Also, with the appropriate management 83 and implementation of simulation tools, it is possible to reproduce the system in a computer 84 environment integrating as many as possible variables. Consequently, different scenarios to take an 85 adequate decision according to the company needs may be created [15].

86 As soon as the simulation was available for manufacturers and education systems, software 87 developers have created new alternatives for the users. In other words, the variety of alternatives 88 went from a general solution to the customized solutions depending on the user needs [16]. Also, the 89 simulation as a strategy of global competition, the construction of separate events that are used to 90 reproduce some real manufacturing situations was more and more common. Although, the 91 increment in the cases of simulation from separate events was positive, the diversification of 92 simulation cases started to be complex. For this reason, the use of the simulation as an alternative of 93 solving problems have generated three types of manufacturing simulation systems: system design, 94 manufacturing system operation, and simulation language/package development [17] which are 95 described in the section below.

96 First, a manufacturing system design is the development of simulation scenarios aimed to 97 design alternatives from production areas that are not installed inside a production flow. In other 98 words, this manufacturing system has been subdivided into the general system design and facility 99 layout, material handling systems design, cellular manufacturing system design, and flexible 100 manufacturing system design. In addition, the manufacturing facilities design is one of the most 101 crucial factors that affect the development of the company regarding its capacity, which determine 102 the manufacturing system performance. Also, a practical layout may reduce manufacturing costs 103 generated by the materials transportation, assembles and sub-assembles inside the production area. 104 In this case, a separate event simulation is an appropriate tool to evaluate the layout and discover 105 potential areas of improvement by evaluating different layout alternatives [17].

106 Second, a manufacturing system operation is integrated by manufacturing planning and 107 scheduling operations, maintenance planning and scheduling operations, real-time control, and 108 operating policies. In one hand, the difference on the manufacturing system design is that the 109 simulation is focused on facilities and the production flow. On the other hand, the manufacturing 110 system operation is defined by management activities; this system integrates the decisions taken by 111 operative personnel, as well as the complexity management of determining the products sequence in 112 the production area [18]. Also, on this system, simulation has the capacity of creating useful 113 scenarios for planners and managers, who take decisions associated with products priorities and 114 personnel requirements, making this strategy favorable for the material requirements, operators, 115 and others.

116 Third, simulation language or package development. At this point, when the simulation 117 software has solved specific needs, companies start hiring experts on programming in order to 118 develop their own system. In other words, simulation opens its alternatives to metamodeling and 119 optimization techniques, explicitly focused on applications in manufacturing systems with unique 120 functions [19].

However, simulation has not been only used by manufacturers as a pure technique. In several cases Lean Manufacturing processes has accomplished its success with the support of other techniques as simulation. For example, the development of new performance material flow indicators [20] validated through simulation modeling, production flow analysis, and logic distribution simulated with the creation and simulation of multi stages [21-23] or the stock control levels with the creation of separate simulation models [24].

As a matter of fact, Lean Manufacturing has been used for the continuous improvement systems in the past, with simulation as an economic optimization strategy and improved systems, Lean has increased its power as a tool, changing the perspective from many companies through the adaptation and imitation of simulation success cases on their own companies [25].

131 In addition, the present paper describes the application of Lean Manufacturing improvement 132 supported by simulation modeling applied in a Seafood Packer Company located in Ensenada City, 133 Mexico. The principal aim was to develop a simulation model to test different layout distributions 134 and generate alternatives to increase the company productivity; the company has identified several 135 problems with the layout distribution within the production area. Also, the main project was to 136 redesign the layout focusing to reduce covered distances by the personnel production during the 137 seafood package process, trying to keep the process as linear as possible. Finally, one of the most 138 significant restrictions associated with the distribution design was the existence of critic 139 cross-contamination points where the product was affected by external factors. In addition, 140 considering that the cross-contamination points is a critical restriction, it was necessary to create 141 production parallel lines to improve the flow process in a linear way, eliminating blocks, stoppages, 142 and waiting times.

143 2. Materials and Methods

- 144 The methodology in the present paper was integrated according to Figure 1 by the following
- 145 stages.
- 146 Stage 1: Description of the processes.

- 147 Stage 2: Develop and analysis of Value Stream Mapping.
- 148 Stage 3: Solution classification for the System.
- 149 Stage 4: Develop of simulation model.
- 150 Stage 5: Analysis of the scenarios.
- 151 Stage 6: Implementation and validation of the improvement.
- 152 To develop and analysis of Value Stream Mapping (VSM) as a Lean Manufacturing tool, a
- 153 model proposed by Lucid Inc. [26]
- 154



161 methodology, where it is possible to identify a path to build a simulation model and generate a

162 specific solution analytically or numerically, for mathematic models as it is in the current case.

163 Particularly, the model integrates as much as possible elements from a real system, always

164 considering this rule: "If there are more details, there will be more information, and with more

165 information, more complexity". Also, it is important to highlight that these models have analogical

166 characteristics that make their development as if they were real models.

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Figure 2. Types of Models [27]

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As it has been previously mentioned, one of the most available tools implemented is the simulation of the system using different software. Additionally, for the present research and according to the company's needs, the Promodel® software was used to develop the simulation model.

175 In order to develop a simulation model, it was necessary to create the diagram from Figure 3; 176 this diagram is a compendium of A. García & Ortega [27]; E. García et al. [28]; Jiménez et al.[28];

177 Kelton [29]; Mourtzis et al.[30].

Moreover, the methodology from Figure 3 was used in the introduction of simulation in the enterprise case, as a phase to introduce new technologies. During the second phase "adaptation", it was possible to match the company's need with the advantages from the methodology supported by technology focusing in the target to improve the system, as well as the customized methodology for the company if it requires further data.

- 183 184
- a. Current machines and work areas distribution.
- b. Value Stream Map of the process for Red Sea Urchin (EZR) and Purple Sea Urchin (EZM).
- c. Alternative machines and workstations distribution, the information about work areas thatcan be used and available.
- d. Identify if the working areas could be re-designed under the current manufacturing systemby considering the activities associated with production.
- e. Data of the necessary production system to build a simulation model to study and analyzethe performance in a simulation environment.
- 192 f. Industry capability to satisfy the forecast demands for (EZR) and (EZM).
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Figure 3. Methodology for the Seafood Packer Company Project, Ensenada.

198 3. Results

199 In order to acquire a result to analyze and define the characteristics from the original 200 production system, it was essential to develop the Value Stream Map (VSM) to identify and measure 201 the times for the processes, because it is focused in two products, that's why it was crucial to create a 202 VSM for each product. In addition, Figure 4 exposes the VSM of EZR; in this Figure is possible to 203 observe a waste time between the operations of "Matadero" and "Cuchareo". Also, as a first 204 perception, this part of the process may be the best alternative to improve them. However, the 205 building characteristics and architecture had to be considered, since one restriction was not to 206 modify the facility. For this reason, it was necessary the layout of the production. Finally, the 207 original layout is portrayed in Figure 6.

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Figure 4. VSM of EZR.

Furthermore, regarding the analysis of EZM through VSM, in Figure 5 is possible to propose by observation a Kaizen event for the activity between "Matadero" and "Cuchareo"; this is the same problem for EZR and is restricted by the building characteristics. In addition, to be more specific with these activities, the operation developed in "Matadero" requires that the employee takes one piece either from EZR or EZP, and open them through the soft part of the mouth using a couple of spoons.





Figure 5. VSM of EZP.

As it has been mentioned, it was impossible to re-design the building, because its structure is old, and it is integrated by different rooms. Also, the owners of the company declare that in this moment is impossible to move out to another facility because of logistic reasons. In addition, Figure 6, shows the areas distribution.







230 Moreover, the first impression to improve the system was to reduce the internal logistic. In 231 order to carry out this analysis, it was fundamental to replicate the layout with the paths that 232 employees have covered to perform production activities. Additionally, Figure 8 presents the 233 original layout with the original routes, which was used during the manufacturing process.

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Figure 7. Original physical layout from the Seafood Packer Company, Ensenada.

As a matter of fact, after defining the VSM and the layout, it was required to define the net used by employees during the process. In addition, the following data was the principal input to design the original layout and the simulation Model. Finally, this information is relevant due to the distance cover by employees:

a. Net from warehouse to "Matadero", this area is integrated by three paths with the next
distances: "N" is used to describe node. N1 to N2 45.37 meters, N2 to N3 19.14 meters and N3 to N1
46.95 meters.

b. Net "ER", this net is integrated by four paths with the next distances: "N" is used to
describe node. N1 to N2 24.39 meters, N1 to N3 18.05 meters, N3 to N4 23.11 meters and N4 to N2
7.78 meters.

c. Net "Cuchareo-matadero" was integrated by four nodes with the next distances: N" is
used to describe node. N1 to N2 11.73 meters, N2 to N3 23.57 meters, N3 to N4 9.65 meters, N4 to N1
27.74 meters, N1 to N3 21.95 meters and N2 to N4 32.10 meters.

d. Net "Cuchareo-cleaning", integrated by six nodes and the next distances associated to each
node: N" is used to describe node. N1 to N2 14.32 meters, N2 to N3 7.86 meters, N3 to N4 13.53
meters, N4 to N1 6.81 meters, N2 to N5 7.65 meters, N5 to N6 7.56 meters, N6 to N3 22.72 meters, N2
to N6 14.86 meters and N5 to N3 15.43 meters.

e. Net "Cleaning-sort", integrated by six nodes and the next distances associated to each
node: N" is used to describe node. N1 to N2 7.71 meters, N2 to N3 28.35 meters, N3 to N1 34.0
meters, N1 to N4 27.61 meters, N4 to N5 12.44 meters, N5 to N2 5.61 meters, N2 to N4 17.17 meters,
N5 to N1 13.29 meters, N3 to N6 11.73 meters, N6 to N1 29.57 meters and N6 to N2 28.84 meters.

After identifying the spaces and equipment availability, the alternative layout was proposed tothe CEO; this alternative is shown in Figure 8.

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Figure 8. New physical layout for the Seafood Packer Company, Ensenada.

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266 Certainly, along with this alternative, new nets were estimated; the layout information is 267 described below:

a. Net from warehouse to "Matadero", this area is integrated by three paths with the next distances: "N" is used to describe node. N1 to N2 103.88 meters, N2 to N3 19.14 meters and N3 to N1 91.02 meters.

b. Net "ER", this net is integrated by four paths with the next distances: "N" is used to describe node. N1 to N2 53.55 meters, N1 to N3 14.73 meters, N3 to N4 48.32 meters and N4 to N2 10.75 meters.

c. Net "Cuchareo-matadero" was integrated by four nodes with the next distances: N" is
used to describe node. N1 to N2 7.28 meters, N2 to N3 5.61 meters, N3 to N4 8.72 meters, N4 to N1
5.33 meters, N1 to N3 9.83 meters and N2 to N4 9.51 meters.

d. Net "Cuchareo-cleaning", integrated by six nodes and the next distances associated to each
node: N" is used to describe node. N1 to N2 7.67 meters, N2 to N3 15.77 meters, N3 to N4 6.73
meters, N4 to N1 12.43 meters, N2 to N5 16.29 meters, N5 to N6 15.14 meters, N6 to N3 18.14 meters,
N2 to N6 22.84 meters and N5 to N3 23.29 meters.

e. Net "cleaning-sort", integrated by six nodes and the next distances associated to each node:
N" is used to describe node. N1 to N2 8.85 meters, N2 to N3 25.15 meters, N3 to N1 27.5 meters, N1
to N4 26.88 meters, N4 to N5 12.28 meters, N5 to N2 23.15 meters, N2 to N4 25.81 meters, N5 to N1
284 24.96 meters, N3 to N6 7.33 meters, N6 to N1 37.67 meters and N6 to N2 14.58 meters.

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286 3.1. Model and Simulation

287 The original simulation model and the improved are indexed in Appendix A and B.

- 289 3.1.1. Assumptions of the model:
- a. Setup time, load or unload time, and processing time are average and constant for allprocesses.
 - b. Scheduling for the production of all products is random and planned to meet lead time.
- c. There are two shifts: one from 6:00 to 13:00 including one break from 10:00 to 10:30, while the second shift is from 14:00 to 21:00 with one break from 18:00 to 18:30, both from Monday through
- 295 Friday.

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- 296 3.1.2. Performance measures:
- a. Resources utilization: The use of each employee can be analyzed with the maximum
 utilization of 90%, the company policy predetermines this percentage.
- b. WIP's: The work in process may determine the constrained works areas and guidelines forthe required distance on WIP.
- 301 3.1.3. Simulation Model
- 302 The model sets the alternative routes according to the physical layout and reproduces the flow
- 303 process for each product as it is illustrated in the flowchart from Figure 9.
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Figure 9: EZR and EZM Process Flow in the Seafood Packer Company, Ensenada.

In addition, it is relevant to mention that this model required modules to supply all the input data required to perform the simulation. In addition, the capacity provided in Capacity Inputs indicates the number of work areas in each process, as well as the schedule cycles for workers to operate. Also, these processed help in determining the amount of capacity that is received; specific data were required for processing each product such as setup, load-unload time, production rates, processing batch size, and flow line. Finally, the simulation team could customize the simulation experiment in the model, such as employees, route distance, and other characteristics.

Furthermore, Table 1 presents the entity summary before the re-design of the process. It is possible to observe the capacity from one week of production, under this scene, it is suitable to produce 885 units of EZR and 823 units of EZM while generating a WIP of 800 EZR and 851 EZM packages. In order to illustrate, Table 2 shows that the percentage of time in Move Logic is a critical issue for the lead time.

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Table 1. Entity Summary.

Name	Total Exits	Current Quantity in System	Average Time in System (Min)	Average Time in Transport (Min)	Average Time Waiting (Min)	Average Time in Operation (Min)	Average Time Blocked (Min)
EZR	885	800	1599.54	1293.35	75.43	6.06	224.69
EZM	823	851	2083.39	1491.46	80.47	6.45	5005.00

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Table 2. Proportion of times for each entity.

Name	% In Move Logic	% Waiting	% In Operation	% Blocked
EZR	80.85	4.71	0.37	14.04
EZM	71.58	3.86	0.30	24.23

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Table 3 represents the location summary before the re-design. Particularly, the percentage of utilization associated with each location is less than 25% in most of them. In addition, it is detected that the location Matadero 2 is the location with the highest percentage of utilization.

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Table 3. Location Summary.

Name	Scheduled Time (Min)	Capacity	Total Entries	Average Time per Entry (Min)	Average Contents	Maximum Contents	Actual Contents	% Utilization
Warehouse EZR	7560	500	760	72.25	7.26	45	30	1.45
Warehouse EZM	7560	650	720	429.74	40.92	92	37	6.29
Supplier	7560	1600	3040	1954.76	786.04	1574	1560	49.12
Matadero2	7410	1	683	7.68	0.70	1	1	70.80
Matadero1	6750	100	730	41.99	4.54	44	1	4.54
Cuchareo	7470	100	729	48.76	4.75	35	4	4.75
Cleaning	7410	40	72	307.40	2.98	8	2	7.46
Sorteo	6180	10	20	515.17	1.66	5	0	16.67
Sorteo2	5760	10	16	674.03	1.87	5	1	18.72
Limpieza2	7440	20	74	282.51	2.80	7	4	14.04

Limpieza3	7470	20	73	316.57	3.09	7	3	15.46
Limpieza4	6960	20	62	361.25	3.21	7	6	16.09
Cuchareo2	7500	20	682	41.73	3.79	12	2	18.97

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By the same token, Table 4 shows the data associated with resources in the original process. It is possible to identify that the employees 4, 5, 6, and 7 have a low percentage of utilization, between 0.5 and 5%. Actually, the reason of this low utilization is due to different perform activities in separated areas of the process and company, which are carry out by workers.

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Table 4. Resources Summary.										
Name	Units	Schedule time (Min)	Work Time (Min)	Number Times Used	Number Times Used (Min)	Average Time Per Usage (Min)	% Utilization			
Employee1	1	4230	1243.64	578	1.0599	1.0917	29.39			
Employee2	1	4230	1681.32	835	0.9919	1.0217	39.73			
Employee3	1	4230	349.56	1411	0.1089	0.1388	8.26			
Employee4	1	4230	196.20	271	0.3213	0.4027	4.63			
Employee5	1	4230	45.74	36	0.6450	0.6255	1.08			
Employee6	1	4230	0.00	0	0.0000	0.0000	0.00			
Employee7	1	4230	8.05	10	0.3839	0.4218	0.19			

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According to the new design of the logic distribution for the process, the result is favorable to achieve the production objective. In Table 5, the number of total exits increases positively for the EZR and EZM finished product, reducing the WIP level. Also, Table 6 presents the percentage reduction in move logic and increase the blocked percentage generated by the WIP

341 reduction in move logic and increase the blocked percentage generated by the WIP.

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Table 5.	Entity	Summary.
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Name	Total Exits	Current Quantity in System	Average Time in System (Min)	Average Time in Transport (Min)	Average Time Waiting (Min)	Average Time in Operation (Min)	Average Time Blocked (Min)
EZR	1488	110	556.96	229.21	52.23	6.06	269.46
EZM	675	771	1014.25	191.88	116.25	6.56	699.55

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 Table 6. Proportion of times for each entity.

Name	% In Move Logic	% Waiting	% In Operation	% Blocked
EZR	41.15	9.37	1.08	48.38
EZM	18.91	11.46	0.64	68.97

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In addition, Table 7 shows the location summary before the re-design. The percentage of utilization associated with each location is under 25% in most of them. Also, it is perceived that the Matadero 2 location got the highest percentage of usage, but it is possible to identify a balance between the other locations.

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Name	Scheduled Time (Min)	Capacity	Total Entries	Average Time per Entry (Min)	Average Contents	Maximum Contents	Actual Contents	% Utilization
Warehouse EZR	6810	1000	1252	106.73	19.6231	111	4	1.96
Warehouse EZM	6870	1000	1120	1197.15	195.1697	565	562	19.51
Supplier	6810	INF	2640	467.19	181.11	339	268	0.01
Matadero2	6750	1	558	10.13	0.83	1	1	83.77
Matadero1	6690	100	1248	89.15	16.63	84	26	16.63
Cuchareo	7320	100	1222	25.01	4.17	29	2	4.17
Cleaning	7350	20	126	192.99	3.30	7	0	16.54
Sorteo	7260	10	34	487.55	2.28	5	4	22.83
Sorteo2	6690	10	15	836.92	1.87	5	0	18.76
Limpieza2	7350	20	52	435.10	3.07	7	3	15.39
Limpieza3	6870	20	118	188.15	3.23	8	6	16.15
Limpieza4	7440	20	59	538.97	4.27	8	3	21.37
Cuchareo2	7410	20	557	56.24	4.22	20	2	21.13

Table 7. Location Summary.

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Moreover, Table 8 describes the information associated with the resources in the original process. It is possible to identify that the utilization of the employee 1, 2, and 3 are balanced, but resources 4, 5, 6, and 7 increase their usage in a low percentage including their extra activities. It can be said that this utilization represents an opportunity to reassign their activities in the production flow.

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Table 8. Resources Summary.	
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Name	Units	Schedule time (Min)	Work Time (Min)	Number Times Used	Number Times Used (Min)	Average Time Per Usage (Min)	% Utilization
Employee1	1	4141	852.26	869	0.4863	0.4939	20.5796
Employee2	1	4141	904.32	937	0.4728	0.4918	21.8386
Employee3	1	4140	1891.31	1779	0.5280	0.5348	45.6840
Employee4	1	4140	281.55	345	0.3959	0.4203	6.8009
Employee5	1	4140	63.99	48	0.6688	0.6643	1.5457
Employee6	1	4140	0.79	1	0.6790	0.1120	0.0191
Employee7	1	4140	8.88	10	0.4586	0.4300	0.2146

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Finally, validation and verification evidence was gathered from the simulation results from simulation tasks, since this was a closed queuing network, there were only two entities that were registered in the system, except the indicated entities that are delivered out of the plant as finished products. In addition, the simulation output was verified by the production department and the proposed model was implemented in the real process. Also, the real data was 99% equal than the simulation model

367 simulation model.

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369 4. Discussion

The development of this project has faced the paradigm of change associated with the use of Lean tools and simulation of the process in a company of small magnitude (according to its dimensions, capabilities, and utilities). Given this effect, the change argument is based on the implementation of Lean tool and the simulation of the process.

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The implementation of Lean has been embraced and thrived in large companies and some medium companies. The impact that these companies have had has been reflected in the growth of their profits and their positioning in the global market according to [1, 4, 9 and 11]. However, [3 and l2] mention that the micro, small industry and the other part of the medium-sized companies face the limitations of these tools, which suffer the high risks generated by equipment and workforce failures, as well as the lack of flexibility or margin of error in meeting delivery dates. This translates into losses of process efficiency and customer confidence.

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On the other hand, large companies justify the cost of simulation implementation in their use, in order to generate analysis scenarios for decision making [25]. Something that micro, small and medium organizations do not consider because their resources are used for reaction activities specifically to the client's needs [15]. Assigning human and financial resources to cloning projects of the processes is an activity that does not fit the needs of employers, although they are aware of the benefits of this tool [16].

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390 Given these limitations, the adoption of these tools should be based on the conviction of the 391 benefits they generate. Although [3, 12 and 15-16] show the disadvantages that Lean and the 392 simulation of the process represent during its adoption, the benefit obtained in this project is 393 opposed to these opinions since there was an increase in production capacity (68%) and inventory 394 reduction (5%). That translated in economic terms represents an increase in the utility of the 395 products of 13%. In a project that takes 60 working days in its development, implementation, and 396 validation, for a small company. Finally, with the results achieved, is necessary to replicate this 397 methodology, for what is left to future research the impact that this proposal can have on micro and 398 small companies.

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400 5. Conclusions

401 Definitely, the difference between the two strategies is the distance reduction on the work area 402 and operations, increasing the total exits generated by the new distribution. In addition, there are 403 other effects associated with these modifications, such as resource utilization, work areas, and WIP. 404 Also, the simulation of the process provides its projection considering the layout design and 405 restrictions.

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407 In fact, along with the planning process capacity, the simulation model was able to validate the 408 production sequencing and distance distribution between the work areas, considering the product 409 demand. Therefore, developing the simulation model is an advantage for the planners who are also 410 able to use the model to improve their system. It can be stated that these changes expose other 411 alternative scenarios, in other words, the development of the simulation model is meant to provide a 412 planning tool, which provides not only the ability to determine the planning process capacity but it 413 valids also the capacity to project the simulations and constraints that affects the expansion demand; 414 in order to identify possible issues that may cause some strategic decision-making problems, as well 415 as evaluate the impact of continuous improvement efforts.

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