# Lean Manufacturing Tools Applied to Human Resource Management and its Impact on Social Sustainability

Luis Javier Márquez-Figueroa[1], Jorge Luis Garcia-Alcaraz[2], José Roberto Diaz-Reza[3], and Alfonso Jesús Gil-López[4]

***Abstract* — This research reports a structural equation model relating Lean Manufacturing Tools associated with Human Resource Management to the benefits obtained in the maquiladora industry of Ciudad Juarez (México). A questionnaire is designed and applied to the regional industry to obtain information about the implementation levels regarding the A3 problem-solving: Decentralization and Multifunctional Working Groups and their relationship with Social Sustainability. The variables are related through six hypotheses validated with empirical information from 411 responses to the questionnaire, giving statistical validation. After quantifying the relationships, findings indicate that the relationship between Multifunctional Working Groups and A3 problem-solving is the strongest of the model. It is concluded that there is enough statistical evidence to state that these tools influence the Social Sustainability in Mexican maquiladora industries, so it is recommended that the Top Management focus its efforts on Human Resource Management to guarantee it, facilitating decision-making in the productive, reducing labor risks and increasing well-being.**

***Keywords* — Lean Manufacturing; Social Sustainability; Structural Equation Model; Human Resource Management; Improvement.**

***Resumen* — Esta investigación analiza un modelo de ecuaciones estructurales que relaciona las herramientas de manufactura esbelta asociadas a la gestión de Recursos Humanos con los beneficios obtenidos en la industria maquiladora de Ciudad Juárez (México). Se diseña y aplica un cuestionario a la industria regional para obtener información acerca de los niveles de implementación respecto de la solución de problemas A3: descentralización y grupos de trabajo multifuncionales y su relación con la sustentabilidad social. Las variables se relacionan a través de seis hipótesis validadas con información empírica de 411 respuestas al cuestionario, otorgando validación estadística. Tras cuantificar las relaciones, los resultados indican que la relación entre los grupos de trabajo multifuncionales y la resolución de problemas A3 es la más fuerte del modelo. Se concluye que existe suficiente evidencia estadística para afirmar que estas herramientas influyen en la sustentabilidad social en las industrias maquiladoras mexicanas, por lo que se recomienda a la dirección enfocar sus esfuerzos en la gestión de Recursos Humanos para garantizar la sustentabilidad social, facilitando la toma de decisiones en lo productivo, reduciendo los riesgos laborales e incrementando el bienestar.**

***Palabras Clave* — Manufactura esbelta; sustentabilidad social; modelo de ecuaciones estructurales; gestión de Recursos Humanos; mejora.**

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## I. INTRODUCTION

LEAN Manufacturing (LM) aims to produce high-quality, low-cost products and services by eliminating waste and minimizing equipment, materials, parts, space, and time. Wastes from transportation, inventory, movements, waits, overprocessing, overproduction, and defects negatively impact yield, quality, and costs, making customers unwilling to pay for these operations [1].

Lean Manufacturing Tools (LMT) are practices and principles that enhance production control, focusing on quality improvement, material flow, process improvement, machinery maintenance, and human resources, leading to widespread acceptance. Thus, depending on the problem, an LMT should be selected to solve it.

Given the importance of LM in the industry, there are many publications on this topic. For example: Pagliosa, et al. [2] show a literature review regarding its applications and Industry 4.0, indicating how the former is the basis of the latter, in other words, companies must have consolidated the LM program before adopting Industry 4.0.

The benefits obtained from implementing LM are many, so it has interested many researchers, some of whom analyze only one tool. For example, Khalili, et al. [3] focus on total quality control programs.

However, one essential benefit of LM is its support for sustainability companies (economic, social, and environmental). Many studies analyze the relationship of LM with some type of sustainability, such as economic, social and environmental [4], social [5], and environmental [6].

However, implementing LM is complex. Not all companies obtain the same results. This has led authors such as Lande, et al. [7] to focus on identifying critical success factors (CSF). However, these results vary and authors report critical factors from different regions. The success of LMT is influenced by the implementation and regional work culture of human resources, including their event planning, problem analysis, education, and teamwork abilities.

This relationship between LM and Human Resource Management (HRM) has been studied before since it is often considered a production philosophy applied to production systems and, as such, is associated with people. The question asked here is: What are those LMT that favor the development of HRM and favor Social Sustainability (SOS)? What is the relationship between LMT and SOS? Authors such as Małysa and Furman [8] discuss LMT for employee safety in manufacturing, including cross-functional teams and problem-solving tools.

Some LMT associated with HRM include Multifunctional Working Groups (MWG). MWG integrates specialists from diverse fields for problem-solving and task execution, but their role in LM environments is yet to be thoroughly analyzed [9].

Another LMT is A3 problem solving (A3), which simplifies problem-solving by presenting production system issues and proposing a solution in a single sheet, requiring synthesis capacity and employee process understanding [10].

Another LMT is Decentralization (DCT), which encourages group participation and shifts power from managers to experienced engineers and operators [11]. This implies that all these groups must have training and decision-making capacity, impacting job satisfaction and motivation.

In Mexico, the application of TML in production systems is of vital importance since there are currently 5156 manufacturing, maquiladora, and export service industries (IMMEX) at the national level. Of which 484 are established in the state of Chihuahua and 322 in Ciudad Juárez with more than 60 % of the state total. These companies generate 2 895 151 direct jobs nationwide, 509 949 jobs in Chihuahua state, and 337 107 jobs in Ciudad Juarez, again, more than 60 % of the state total. Comparing Ciudad Juarez against the cities with the greatest influence in Mexico's manufacturing industry, we can obtain Tijuana, the city with the most IMMEX companies: 596. Next to it, Ciudad Juarez has 322, and the difference between the number of employees is 259 968 for Tijuana and 337 107 for Ciudad Juarez, even with a smaller number of companies, demonstrating the economic and social importance of this sector. Therefore, the maquiladora industry requires further study [12].

This paper analyzes the relationship between MWG, the A3, and DCT and its impact on SOS in a manufacturing environment, as they have shown high efficiency in other sectors. This study's main contribution is that it provides empirical, quantitative, and statistical evidence regarding the relationships among those variables, enabling managers to optimize HRM skills and integrate them into company goals for better SOS, facilitating decision-making to managers, reducing labor risks, and increasing well-being.

This paper is organized as follows. After a brief introduction, section two presents a literature review, defining variables and justifying relationships. Section three describes the methodology. Section four analyzes results and section five reports conclusions and industrial implications.

## II. LITERATURE REVIEW AND HYPOTHESIS

### *A. Multifunctional Working Groups (MWG)*

MWG is an approach that involves cross-training experts from various specialties to solve problems, allowing them to adapt to the production line environment and perform significant tasks, providing necessary support. MWG has been reported in the literature. For example, Schretlen, et al. [13] apply Lean Six Sigma tools to have safe, on-time, effective and efficient deliveries, focusing their efforts on problem-solving.

### *B. A3 Problem solving (A3)*

The A3 is a useful LMT for problem-solving that lets us find the root causes of problems, action plans for implementing the improvements found, and evaluation metrics. In an LM environment, A3 implementation involves a single-page report with background information, a current situation diagram, target condition, and root cause analysis, following the PDCA cycle for standard problem-solving. MWG, a structured approach, combines diverse expertise to tackle complex problems, enhancing its effectiveness with A3 [14], and the following hypothesis is proposed:

H1. MWG directly and positively affects implementing A3.

### *C. Decentralization (DCT)*

DCT is an organizational strategy that enables autonomous decision-making among subsystems, promoting self-organization and flexibility. DCT utilizes deep learning and machine learning for rapid decision-making, facilitating seamless organization and customized products.

The MWG-DCT combination enhances organizational sustainability by fostering flexibility, reduces rule-boundness, and enables faster, better operational decisions, enhancing organizational innovation and performance [15]. So, the following hypothesis is proposed:

H2. MWG directly and positively affects DCT implementation.

Combining A3 with DCT promotes sustainable improvement across organizations, empowering local teams to solve problems while aligning with organizational goals and strategies. The A3 and DCT combination can significantly improve efficiency and effectiveness in underperforming firms through radical organizational changes [16].hen the following hypothesis is proposed:

H3. A3 directly and positively affects DCT implementation.

### *D. Social Sustainability (SOS)*

SOS is a managerial approach that integrates social considerations into business practices to ensure employee well-being, equitable treatment, and positive social impacts, promoting social justice and enhancing the overall quality of life, including worker rights and labor conditions. The A3 offers numerous advantages, including identifying and tackling SOS issues within organizations focusing on workplace safety, social justice, and environmental impact [17]. Then, the following hypothesis is proposed:

H4. A3 directly and positively affects implementing SOS.

MWG fosters collaboration among diverse departments, enhancing an organization's response to new sourcing demands and maximizing resource utilization when executed effectively. MWG is integrated from different departments and backgrounds, allowing diverse perspectives and expertise in problem-solving and decision-making. MWG groups, involving employees from various functions, can develop sustainable practices addressing social issues like worker well-being, safety, inclusiveness, and continuous learning, fostering communication, knowledge sharing, and collective decision-making [18]:

H5. MWG directly and positively affects implementing SOS in the IMMEX.

DCT and SOS can enhance community involvement in development projects, promoting inclusive decision-making and catering to their specific social, economic, and environmental needs [19]. Combining DCT and SOS enhances environmental awareness, sustainable resource management, and decision-making in infrastructure development, fostering ownership and responsibility for project outcomes, and then the following hypothesis is proposed:

H6. DCT directly and positively affects implementing SOS in the IMMEX.

Figure 1 illustrates the different relationships between variables to distinguish the hypotheses established.

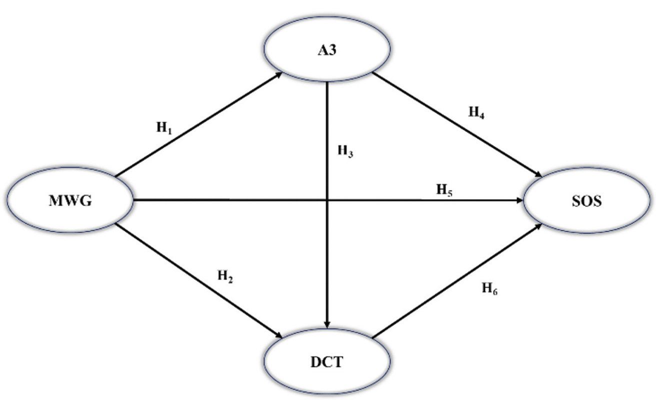


Fig 1. Proposed model

## III. METHODS

### A. Development of the questionnaire

A literature review is conducted to identify previous research regarding LM associated with HRM and SOS and generate a preliminary questionnaire to assess implementation levels and SOS benefits obtained in the industry. This first questionnaire requires judges and industry managers to validate for a better regional context adaptation. It has three sections: demographic information, LMT and SOS benefits, all of them adapted to regional contexts.

The questionnaire will be scored on a 5-point Likert scale, with 1 indicating no activity or no benefit and 5 indicating always occurring or always obtained [20]. Interested readers can see the complete questionnaire as supplementary material.

### B. Application of the questionnaire

The questionnaire information is used to validate relationships between variables in Mexican Manufacturing Industries (MMI) in Ciudad Juárez- México, during the COVID-19 contingency. It is integrated electronically into Google Forms to avoid missing values.

Email invitations are sent from January 15 to August 1, 2022 to potential respondents for a project questionnaire. If no response is received, the respondent is discarded.

Respondents in the manufacturing industry with HRM-focused LMT implementation knowledge, one-year industry experience, and two LM project completions must have experience in production or manufacturing departments.

### C. Information gathering and debugging

On October 5, 2022 a file was downloaded from the Google Forms platform and integrated into SPSS v.25 software to develop debugging operations such as the following [21]:

- Non-committed respondents are identified. Calculating the standard deviation and cases with values less than 0.5 are discarded.
- Extreme values are identified by standardizing each item, where the median replaces absolute values greater than 4 or -4.

### D. Descriptive analysis of the sample and items

The software SPSS v.25 software was used for the descriptive analysis of the information, given its ease of use and acceptance in scientific reports [22]. Specifically, demographic information is used to describe the sample in cross-tabulations. We use the median to measure central tendency, with high values indicating consistent benefits and low values indicating the opposite. The Interquartile Range (IQR) measures dispersion, with high values indicating a lack of consensus and low values indicating higher consensus.

### E. Structural Equation Model (SEM)

#### 1) Latent Variable Validation:

The variables in Fig. 1 are four latent variables and are validated according to the following indices [23]:

- R-squared and adjusted R-squared to measure parametric predictive validity (values ≥0.2 are accepted) and Q-squared to measure parametric validity (positive values like R-squared are accepted).

- Cronbach's alpha and the composite reliability index to measure internal validity (values ≥0.7 are accepted).
- Variance inflation index (VIF) to measure the collinearity (values ≤5 is accepted).
- The average variance extracted (AVE) to measure convergent validity, where values greater than 0.5 are accepted.

Indices like Cronbach's alpha and VIF are estimated iteratively by eliminating items, while other indices like PLS reliability, additional reliability coefficients, discriminant validity and T ratios are also included.

*2) Model validation:*

Structural equation modeling (SEM) is used to validate the relationships between variables, using the partial least squares (PLS) approach and integrated into WarpPLS 7.0 software. The PLS-SEM is used since it is recommended for small samples with variables not following normal distributions or ordinal scales. Before interpreting the PLS-SEM model, the model efficiency indices are evaluated at a confidence level of 95 % [24]:

1. The average R-squared (ARS) and average adjusted R-squares (AARS) measure the model's predictive validity, where the associated p-value must be less than 0.05.
2. The average variance inflation factor (AVIF) and average full variance inflation factor (AFVIF) measure collinearity, where values less than 5 are accepted.
3. The Tenenhaus GoF measures the data's fit, which must be greater than 0.36.

*3) Direct effects - Validation of hypotheses:*

The SEM model validates hypotheses by analyzing direct effects. A standardized parameter β is obtained, testing the null hypothesis H0. $\beta=0$, versus the alternative hypothesis $\beta\neq0$ with 95 % confidence [24]. If it is concluded that $\beta\neq0$, then there is sufficient statistical evidence to say there is a relationship between the analyzed variables, whether positive or negative.

Additionally, effect size (ES) measures the variance explained by independent variables on dependent variables for each direct effect, with the R-squared value representing the sum of all ES on a dependent variable.

*4) The sum of indirect and total effects:*

This study reports indirect effects between variables through mediators, where a β parameter and its p-values are reported, testing their statistical significance. Finally, summarizing direct and the sum of indirect effects, the total effects are calculated, reporting the β their p-values.

*F. Sensitivity analysis*

The WarpPLS 7.0 software reports the standardized indices, which allows for performing a sensitivity analysis based on probabilities to determine the occurrence of scenarios for the variables [24]. This study analyzes probabilities for high scenarios with standardized variables having values greater than one $P(X\geq1)$ and low scenarios with values lower than one $P(X\leq-1)$. This study reports the probability:

1. When a variable occurs independently at high or low levels.
2. When two variables in a relationship occur together in a combination of high or low levels.
3. When a dependent variable occurs, given that an independent variable occurred at a high or low level.

## IV. RESULTS

*A. Descriptive analysis of the sample*

The research analyzes 411 responses from 1 611 emails, and Table I reveals that engineers are the most frequent job position, with 243 responses, and the automotive sector has the highest participation rate at 148.

TABLE I
INDUSTRY SECTOR AND JOB POSITION (TOTAL OF PEOPLE)

| **Industrial Sector** | **Job position** | | | | **Total** |
|---|---|---|---|---|---|
| | **Mngr**[1] | **Eng**[2] | **Supv**[3] | **Tech**[4] | |
| Automotive | 20 | 90 | 19 | 19 | 148 |
| Aeronautics | 2 | 2 | 1 | 0 | 5 |
| Electric | 1 | 10 | 3 | 2 | 16 |
| Electronics | 7 | 32 | 10 | 7 | 56 |
| Logistics | 1 | 10 | 2 | 2 | 15 |
| Machining | 2 | 5 | 2 | 4 | 13 |
| Medical | 5 | 43 | 10 | 14 | 72 |
| Rubber and plastics | 0 | 5 | 2 | 1 | 8 |
| Textiles and clothing | 0 | 3 | 0 | 0 | 3 |
| Other | 12 | 43 | 11 | 9 | 75 |
| Total | 50 | 243 | 60 | 58 | 411 |

1Manager; 2Engineer; 3Supervisor; 4Technician

Table II shows the gender and years of experience in 411 responses, where 177 women had 2-5 years of experience, while 234 men had 2-5 years. The most extensive respondents had 2-5 years and 5-10 years of experience, indicating knowledge of LMT implementations.

TABLE II
YEARS OF EXPERIENCE

| **Gender** | **Years of experience at your job?** | | | | **Total** |
|---|---|---|---|---|---|
| | **1 to 2** | **2 to 5** | **5 to 10** | **More than 10** | |
| Female | 38 | 68 | 42 | 29 | 177 |
| Male | 45 | 71 | 61 | 57 | 234 |
| Total | 83 | 139 | 103 | 86 | 411 |

The main industrial sectors in Ciudad Juarez are automotive, medical and electronics, so it is assumed that the results are more related to these types of companies.

### *B. Descriptive analysis of the items*

Table III reveals that respondents consistently benefit from implementing tools like MWG, A3, DCT, and SOS, with the highest median item in the SOS theme being improved employee health and the highest median item in the DCT theme being financial power delegation.

TABLE III
DESCRIPTIVE ANALYSIS OF THE ITEMS

| Items | Median | IQR[5] |
|---|---|---|
| **MWG**[1] | - | - |
| Cross-training of workers is a regular feature | 4 093 | 1 519 |
| Empowerment of workers is enough | 4 019 | 1 379 |
| Projects are finalized with the consent of experts in various areas | 4 149 | 1 412 |
| The quality circle concept is utilized holistically | 4 102 | 1 454 |
| **A3**[2] | - | - |
| Report writing is done on a single page containing text, images, diagrams, and graphs that enrich and clarify the data | 4 158 | 1 504 |
| Report writing is mainly based on PDCA | 4 094 | 1 487 |
| The report contains background information, a diagram of the current situation, the target condition, and a root cause analysis | 4 173 | 1 468 |
| A follow-up/audit is made, the results of the audit plan, and, if necessary, recommendations on how the subsequent A3 Reports will become standard work | 4 229 | 1 435 |
| **DCT**[3] | - | - |
| Authority and responsibility are delegated to lower levels as well | 4 027 | 1 514 |
| Financial power is also delegated at different levels | 3 817 | 1 729 |
| The workload is equally distributed at different levels and structured | 3 924 | 1 617 |
| Authority and responsibility are communicated and published | 4 013 | 1 505 |
| **SOS**[4] | - | - |
| Improved employee health | 4 232 | 1 464 |
| Improved labor relations | 4 206 | 1 446 |
| Improved morale | 4 167 | 1 467 |
| Improved community health and safety | 4 159 | 1 481 |

1 Multifunctional Working Groups; 2 A3 Problem Solving; 3 Decentralization; 4Social Sustainability; 5 InterQuartile Range.

### *C. Structural Equation Model (SEM)*

#### *1) Validation of variables:*

The validation indices for the SEM are according to cutoff values for parametric validity, Cronbach's alpha, composite reliability, average variance, non-parametric predictive validity and total collinearity, all of them shown in Table IV. This indicates that all variables can be integrated into the SEM.

TABLE IV
VALIDATION OF LATENT VARIABLES OF LM APPLIED IN THE QUESTIONNAIRE

| Index | SOS | A3 | MWG | DCT | Best if |
|---|---|---|---|---|---|
| R-squared[1] | 0.542 | 0.483 | - | 0.576 | >= 0.2 |
| R-squared adjusted | 0.539 | 0.482 | - | 0.574 | >=0.2 |
| Composite Reliability | 0.957 | 0.954 | 0.927 | 0.930 | >=0.7 |
| Cronbach's Alpha | 0.940 | 0.936 | 0.894 | 0.900 | >=0.7 |
| AVE[2] | 0.847 | 0.839 | 0.760 | 0.770 | >=0.5 |
| Full Collinearity (VIF[3]) | 2.187 | 2.148 | 2.655 | 2.602 | <=3.3 |
| Q-squared[4] | 0.542 | 0.483 | - | 0.577 | >=0.2 |

1Coefficient of determination; 2Average variance extracted; 3Variance Inflation Factor; 4Predictive validity.

#### *2) Model validation:*

Table V displays the efficiency indexes of the model, showing predictive validity for values requiring a p-value less than 0.05, no collinearity problems for AVIF and AFVIF, and adequate goodness of fit for a value of 0.655, indicating the model's effectiveness. These values indicate that the model can be interpreted.

TABLE V
MODEL EFFICIENCY INDICES

| Index | β, p-value | Best if |
|---|---|---|
| APC[1] | 0.389, p<0.001 | p<0.05 |
| ARS[2] | 0.534, p<0.001 | p<0.05 |
| AARS[3] | 0.532, p<0.001 | p<0.05 |
| AVIF[4] | 2.207 | <=3.3 |
| AFVIF[5] | 2.398 | <=3.3 |
| Tenenhaus GoF[6] | 0.655 | >=0.36 |

1Average path coefficient; 2 Average R-squared; 3Average adjusted R-squared; 4 Average Block VIF; 5 Average full collinearity VIF; 6 Good of Fitness.

Figure 2 shows the model's results, indicating 99.9 % confidence in the relationships with p-values less than 0.001 and R2 values for dependent variables like SOS, A3, and DCT.

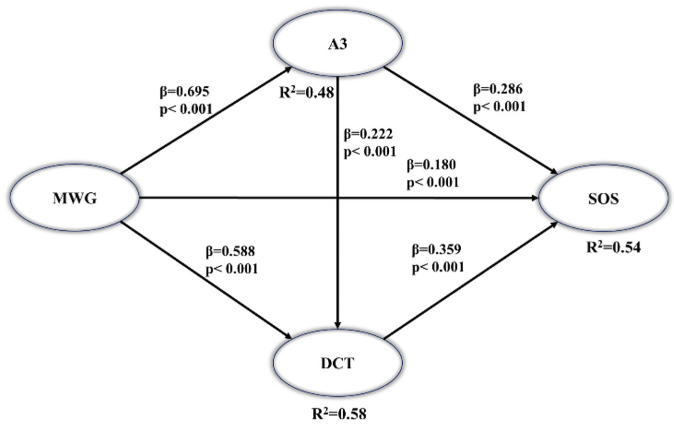


Fig 2. Evaluated model

*3) Hypotheses validation- Direct effects:*

Table VI presents the direct effects of the research, indicating hypotheses, β value, p-value, ES, and decision taken. The p-values confirm statistical significance for all relationships, with 99.9 % confidence. For example, H1 shows that MWG has a direct and positive effect on A3 with β=0.695 and explains 48.3 % of its variability.

TABLE VI
SUMMARY OF TESTED HYPOTHESES

| Hi | Relation | β (p-value) | ES[1] | Decision |
|---|---|---|---|---|
| H1 | MWG→A3 | 0.695 (<0.001) | 0.483 | Accept |
| H2 | MWG→DCT | 0.588 (<0.001) | 0.436 | Accept |
| H3 | A3→DCT | 0.222 (<0.001) | 0.140 | Accept |
| H4 | A3→SOS | 0.286 (<0.001) | 0.183 | Accept |
| H5 | MWG→SOS | 0.180 (<0.001) | 0.116 | Accept |
| H6 | DCT→SOS | 0.359 (<0.001) | 0.243 | Accept |

1Effect Size

Table VIII displays total effects with p-values less than 0.001, indicating 99.9 % confidence in model-based estimates. MWG→SOS, MWG→A3, and MWG→DCT have the highest β values.

*4) The sum of indirect and total effects:*

Table VII shows the indirect effects on latent variables, where all of them are statistically significant. The highest value indicates the importance of implementing MWG in productive areas of the MMI.

TABLE VII
THE SUM OF INDIRECT EFFECTS

| To | From | |
|---|---|---|
| | A3 | MWG |
| SOS | β=0.080, p=0.011 ES=0.051 | β=0.466, p<0.001 ES=0.301 |
| DCT | - | β=0.155 (p<0.001) ES=0.115 |

TABLE VIII
TOTAL EFFECTS

| - | A3 | MWG | DCT |
|---|---|---|---|
| SOS | β=0.366 (p<0.001) ES=0.234 | β=0.646 (p<0.001) ES=0.417 | β=0.359 (p<0.001) ES=0.243 |
| A3 | - | β=0.695 (p<0.001) ES=0.483 | - |
| DCT | β=0.222 (p<0.001) ES=0.140 | β=0.742 (p<0.001) ES=0.551 | - |

*D. Sample size*

The sample size is suitable for this model. The results are obtained from 411 responses, and the path coefficient in the relationship MWG to SOS is 0.180. So for the validation of the sample size we performed a test in WarpPLS v.7.0 to define the minimum required using two methods: Inverse Square Root Method and Gamma-Exponential Method. For this path coefficient the minimum required sample size is 191 and 178 respectively, using a significance level of 0.05 and a required power level of 0.800.

*E. Sensitivity analysis*

Table IX reveals high scenarios with a "+" and low scenarios with a "-" symbol. The probability of obtaining A3+ given MWG+ indicates the importance of multifunctional teams in solving production problems. The same relationship holds for obtaining DCT+ given A3+, suggesting top management should focus on A3 and problem-solving for positive company DCT results.

The probability of obtaining A3- given MWG- is high at 61.2 %, indicating the need for multifunctional teams in problem resolution within the productive area, as failure in A3 is high without MWG implementation.

The "Discussion of Results" chapter shows a more in-depth analysis.

TABLE IX
SENSITIVITY ANALYSIS

| **Level** | **-** | **MWG+** | **MWG-** | **A3+** | **A3-** | **DCT+** | **DCT-** |
|---|---|---|---|---|---|---|---|
| - | Probs | 0.146 | 0.163 | 0.234 | 0.170 | 0.202 | 0.148 |
| A3+ | 0.234 | &=0.114<br>If=0.783 | &=0.007<br>If=0.045 | - | - | - | - |
| A3- | 0.170 | &=0.002<br>If=0.017 | &=0.100<br>If=0.612 | - | - | - | - |
| DCT+ | 0.202 | &=0.109<br>If=0.750 | &=0.002<br>If=0.015 | &=0.146<br>If=0.625 | &=0.005<br>If=0.029 | - | - |
| DCT- | 0.148 | &=0.010<br>If=0.067 | &=0.090<br>If=0.552 | &=0.017<br>If=0.073 | &=0.063<br>If = 0.371 | - | - |
| SOS+ | 0.248 | &=0.105<br>If=0.717 | &=0.012<br>If=0.075 | &=0.148<br>If=0.635 | &=0.012<br>If=0.071 | &=0.136<br>If=0.675 | &=0.010<br>If=0.066 |
| SOS- | 0.168 | &=0.005<br>If=0.033 | &=0.097<br>If=0.597 | &=0.010<br>If=0.042 | &=0.095<br>If=0.557 | &=0.005<br>If=0.024 | &=0.083<br>If=0.557 |

## V. DISCUSSION OF RESULTS

### *A. From the SEM*

H1. MWG directly and positively affects A3 since β=0.695, explaining up to 48.3 % variance and indicating that using personnel from different departments for problem-solving can lead to efficient and quick solutions. This result agrees with Huang, et al. [25], who say that organizations increasingly turn to MWG and A3 in today's business environment to increase efficiency, improve communication and drive innovation.

H2. MWG directly and positively impacts DCT since β=0.588, explaining 43.6 % of the variance and indicating that DCT responsibility and authority in work teams facilitates this process, with personnel from different departments contributing. These findings agree with Benyahya and Macurová [26], who say that MWG can help reduce supervision costs since team members are responsible for their work.

H3. A3 directly and positively affects DCT since β=0.222, explaining 14 % of its variance since organizational communication confirms access to economic information. These findings agree with Prusak and Jursová [27], who suggest that a decentralized organizational structure can provide organizations with several benefits, including greater efficiency in using information technologies, greater creativity and imaginative solutions to problems, and greater innovativeness.

H4. A3 directly and positively affects SOS since β=0.286, explaining 18.3 % of the variance since good problem-solving results, efficient processes, and improved working conditions, including employee safety and health, can be solved. These findings agree with Baumgartner [28], who says that integrating SOS criteria into the A3 process can help organizations identify opportunities to save costs and optimize resources.

H5. MWG directly and positively impacts SOS since β=0.180, explaining 11.6 % of the variance, since promoting cross-trained teams and empowered workers improves morale and labor relations and reduces work pressure through support from coworkers. This result agrees with Kociuba and Szafranek [29], who say that using MWG in SOS initiatives can facilitate the integration of different internal functions to ensure that objectives related to sustainable development are met.

H6. DCT directly and positively and positively affects SOS since β=0.359, explaining 24.3 % of the variance since it equates workload distribution and responsibilities and improves worker relations and morale. These results agree with Miralles-Quirós et al. [30], who say that DCT can lead to lower initial investments and operating costs for maquiladoras, allowing them to invest in financially sustainable practices.

### *B. Sensitivity analysis*

This research analyzes the probability of occurrence of MWG in HRM programs, supported by A3 and DCT, and based on Table IX information, the following conclusions are reached.

MWG+ increases the probability of occurrence for A3+, DCT+, and SOS+ production line problems at 0.783, 0.750 and 0.717, respectively, indicating that the managers must generate MWG+ to gain benefits. However, MWG+ is negatively associated with A3-, DCT-, and SOS- since the conditional probabilities are 0.017, 0.067, and 0.033, respectively.

Additionally, MWG- has a low association with A3+, DCT+, and SOS+ since the conditional probabilities are 0.045, 0.015 and 0.075, respectively, indicating that investments in MWG always offer some benefits. However, there is a high risk when MWG- because it favors A3-, DCT-, and SOS- with conditional probabilities at 0.612, 0.552 and 0.597.

When A3+ occurs, it favors DCT+ and SOS+ since the conditional probabilities are 0.625 and 0.635, so managers must promote the A3 technique for solving problems at production lines. Additionally, A3+ has a low relationship with DCT -and SOS- since the conditional probabilities are 0.073 and 0.043.

However, A3- is a risk for managers since it is highly associated with DCT -and SOS- with conditional probabilities of 0.371 and 0.557, respectively, and it is almost not associated with DCT+ and SOS+ since probabilities are only 0.029 and

0.071, indicating that investments to work and understand A3 technique always offer some benefits.

Finally, it is demonstrated that DCT+ favors the SOS+ occurrence with a conditional probability of 0.606, indicating that integrating employees into the decision-making process guarantees satisfaction. Additionally, it is observed that DCT+ is not associated with SOS- since the conditional probability is 0.024, indicating that DCT rarely generates SOS. However, there is a risk if DCT- occurs since then, SOS- can appear with a probability of 0.557, indicating that excluding workers from the decision-making process can affect motivation. Moreover, DCT- is not associated with SOS+ since the probability is only 0.010.

## VI. CONCLUSION

Using a structural equation model, the study analyzes the relationships between MWG, A3, DCT, and SOS. Results show that programs promoting MWG encourage problem-solving methodologies (A3) and distribute authority and responsibilities among workers and departments (DCT). These LMT programs significantly impact the company's social benefits (SOS).

Low implementation of HRM tools without work teams from different departments can risk problem identification and solutions within productive areas, avoid distributing authority and responsibilities among workers, and hinder the company's achievement of social objectives.

DCT greatly influences the development of SOS in the MMI, so having decentralized teams is essential in companies that need to increase their level of SOS implementation.

On the other hand, the MWG has a less direct impact on SOS. However, it is the tool that most influences DCT. Management is urged to focus their efforts on implementing MWG's to increase SOS indirectly through a good A3 and DCT.

## VII. LIMITATIONS AND FUTURE RESEARCH

The research was conducted during the COVID-19 pandemic, limiting access to companies and reducing the number of potential respondents. Surveys were answered online to managers and engineers in the Mexican Maquiladora Industry, which can be a limitation.Then future works are planned as follows:

- Continue surveys and evaluations to increase sample size and analyze LMT with environmental and economic sustainability as part of the holistic analysis.
- The survey will be applied to other Mexican cities and states in Mexico where Maquiladora Industry operates. This will let us compare cultural, social, and geographical characteristics.

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