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Research Article

Measuring the Complex Construct of Macroergonomic Compatibility: A Manufacturing System Case Study

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Macroergonomic compatibility (MC) refers to the extent to which macroergonomic factors and elements (MFEs) interact positively with humans. It is one of the most complex constructs to measure in work systems and in ergonomics. The goal of this paper is to determine the levels of MC in a manufacturing system. As methods, we use the macroergonomic compatibility index (MCI) and the Macroergonomic Compatibility Questionnaire (MCQ). The MCQ was administered in its three versions (i.e., worker version, expert version, and medical department version) to collect data about the macroergonomic practices implemented in the manufacturing company. Regarding results, all the macroergonomic factors and most of the macroergonomic elements showed a low level of MC; that is, MCI < 0.7. Only macroergonomic elements *Education, Knowledge, and Skills* reached a medium level; namely, MCI $= 0.709$. The factor with the highest level of MC was the Person factor (MCI $= 0.328$). Similarly, the whole manufacturing system showed a low level of MC. In conclusion, the studied manufacturing company requires urgent macroergonomic interventions. Also, we found that the MCI can effectively measure the level of MC of MFEs and can guide the implementation of macroergonomic practices (MPs) and explain the MC construct.

1. Introduction

Ergonomics is the science that focuses on adapting the work to the people who perform it. Ergonomics studies how people do their work, what objects (tools and technology) they need, the physical conditions (facilities and environment) where people work, and the psychosocial situations of the work [1, 2]. According to Dul et al., "ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize well-being and performance" [3]. Carayon [4] and the International Ergonomics Association [5] provide this same definition of ergonomics.

In the manufacturing industry, ergonomics is viewed as a science that deals with complex issues of manufacturing systems. Firstly, ergonomics seeks the well-being, comfort, and health of employees. Employees, as human beings, have different physical and psychological traits and possess different skills [6, 7], which make them unique beings. Secondly, ergonomics considers the interactions between employees and the other system elements [3], including organizational elements (e.g., work schedules and supervisory styles), work technology and tools, workload, time pressure, and cognitive load. The appropriate interaction between these elements and employees can be difficult to achieve [2] and can compromise or hinder employee performance and well-being. Therefore, to guarantee employee safety and health while also increasing performance and optimizing manufacturing systems, ergonomics relies on multiple disciplines, including anatomy, biomechanics, design, architecture, psychophysics, physiology, psychology, engineering, management, genetics, hygiene, and medicine [8–10].

Compatibility is a key term in ergonomics. According to Bordeaux et al. [11], two objects are compatible when they can properly interact while having opposite behaviors. This definition implies that two objects are compatible when they are complementary in terms of capabilities and limitations. In other words, compatible objects match each other to achieve specific goals. In this sense, compatibility refers to the ability of an object to adapt to the capabilities, limitations, and needs of another object to perform a specific function. From an ergonomic perspective, compatibility is therefore the capability of an object (e.g., tool, machine, workstation, workspace, or work system) to adapt to humans. In fact, ergonomic compatibility is an integrated design criterion; it is expressed in terms of human capabilities and limitations, and it focuses on improving employee safety and health, productivity, and work quality [12, 13]. Thus, considering the number of interactions that occur in a manufacturing system, ergonomic compatibility is a complex construct.

Ergonomics as a science is divided into two main subdisciplines: microergonomics and macroergonomics [14–16]. The goal of microergonomics is to improve employee performance by enhancing detailed issues about man-machine interaction (body postures, task design, equipment/products, and tools) for a specific task [17, 18]. Likewise, microergonomics can increase man-machine interaction compatibility. Nowadays, there is a wide range of techniques that implicitly measure ergonomic compatibility (or incompatibility) at a microergonomic level. On the other hand, macroergonomics is a top-down sociotechnical systems approach concerned with the analysis, design, and evaluation of work systems (a work system consists of two or more people interacting with some form of job design, hardware or software, internal or external environment, and an organizational design [19]). Namely, macroergonomics is concerned with human-work system interaction [19, 20]. The main goal of macroergonomics is to harmonize work systems at both micro- and macroergonomic levels to improve productivity, safety, and health (i.e., employee life quality) [21]. Consequently, macroergonomics can increase human-work system interaction compatibility. In this sense, macroergonomic compatibility is more complex than microergonomic compatibility, as it comprises all employee-work system interactions; therefore, macroergonomic compatibility is more difficult to measure and evaluate than microergonomic compatibility. Figure 1 illustrates the ergonomic compatibility complexity (ECC) that is necessary to optimize ergonomic compatibility at both micro- and macroergonomic levels.

As previously mentioned, a wide range of methodologies and techniques can measure microergonomic compatibility in the manufacturing industry. For instance, in [22, 23], the researchers developed a methodology to evaluate the ergonomic incompatibility content (EIC) of advanced manufacturing technology (AMT), whereas the authors of [24] developed an expert system to measure this EIC of AMT. Unfortunately, macroergonomic research has not evolved in the same way, and, until now, macroergonomics lacks an unanimously accepted methodology for measuring macroergonomic compatibility. As Karwowski [25] states, the lack of a universal matrix to quantify and measure macroergonomic compatibility is an important obstacle to demonstrating the value of ergonomics as a science and as a profession. To overcome this obstacle, researchers such as Wallace et al. [26], Koyuncu et al. [27], Pacholski and Szczuka [28], and Realyvásquez-Vargas et al. [2] have proposed their own macroergonomic compatibility measurements. The latter [2] proposed a mathematical model called macroergonomic compatibility index (MCI) to measure the macroergonomic compatibility of manufacturing systems at three hierarchies: macroergonomic elements, macroergonomic factors, and manufacturing systems. Also, the model takes into account the macroergonomic variables (factors and elements) most studied in the literature [29–31].

In Mexico, the majority of the manufacturing companies are not familiarized enough with the impact of macroergonomic practices (MPs) and their long-term benefits. To address this deficiency, our research work seeks to implement the MCI proposed by Realyvásquez-Vargas et al. [2] to measure the level of macroergonomic compatibility of a manufacturing industry at the three hierarchies: macroergonomic elements, macroergonomic factors, and manufacturing system. Consequently, the MCI will be able to determine which work variables require urgent macroergonomic intervention through MPs. In the end, the goal of implementing the MCI is to promote MPs implementation in Mexican manufacturing industries and help the studied company obtain macroergonomic compatibility benefits.

2. Research Context

The manufacturing sector is a key to the industrial development of Mexico. The Mexican manufacturing industry includes 5,024 manufacturing plants that generate 2,280,504 direct jobs around the country and produce $7,233.37 of USD in billings each quarter of the year [32, 33]. Chihuahua, one of the 31 states of Mexico, provides 13.6% of the national manufacturing industry income. The state employs 323,794 workers across its 477 companies. This research is conducted in Ciudad Juárez, Chihuahua, in the plant of one of the world's most appreciated automotive leather suppliers. The plant employs around 2,200 employees and makes continuous efforts to improve its processes. Also, the company currently seeks to implement and enhance the benefits of MPs.

3. Materials and Methods

3.1. Materials. The Macroergonomic Compatibility Questionnaire (MCQ) was administered to collect data about the MPs implemented in the plant [2, 33]. The MCQ has three versions: the worker version (MQC-WV), the medical department version (MCQ-MDV), and the experts version (MCQ-EV). Only the MCQ-WV and the MCQ-EV were used to obtain the numerical values of the MCI. The MCQ-WV reports how the employees perceive the MPs are implemented in the plant or company. Table 1 shows a sample of both the MCQ-WV and the MCQ-EV.

Figure 2 presents the hierarchical arrangement of the macroergonomic factors and elements (MFEs) studied through the MCQ.

3.2. Method. This section describes the method used to determine the level of macroergonomic compatibility of the

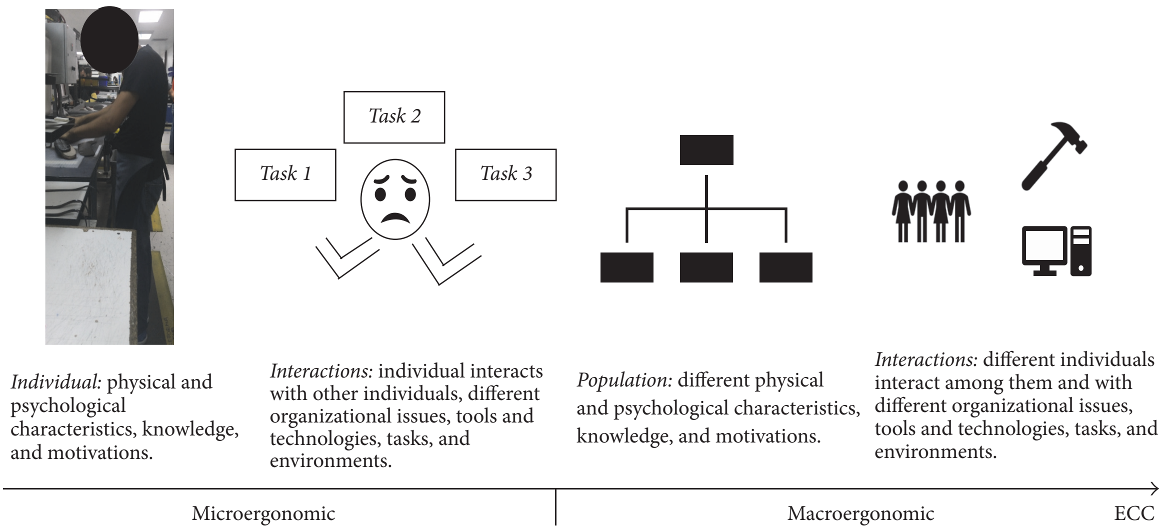

Figure 1: Ergonomic compatibility complexity at micro- and macroergonomic levels.

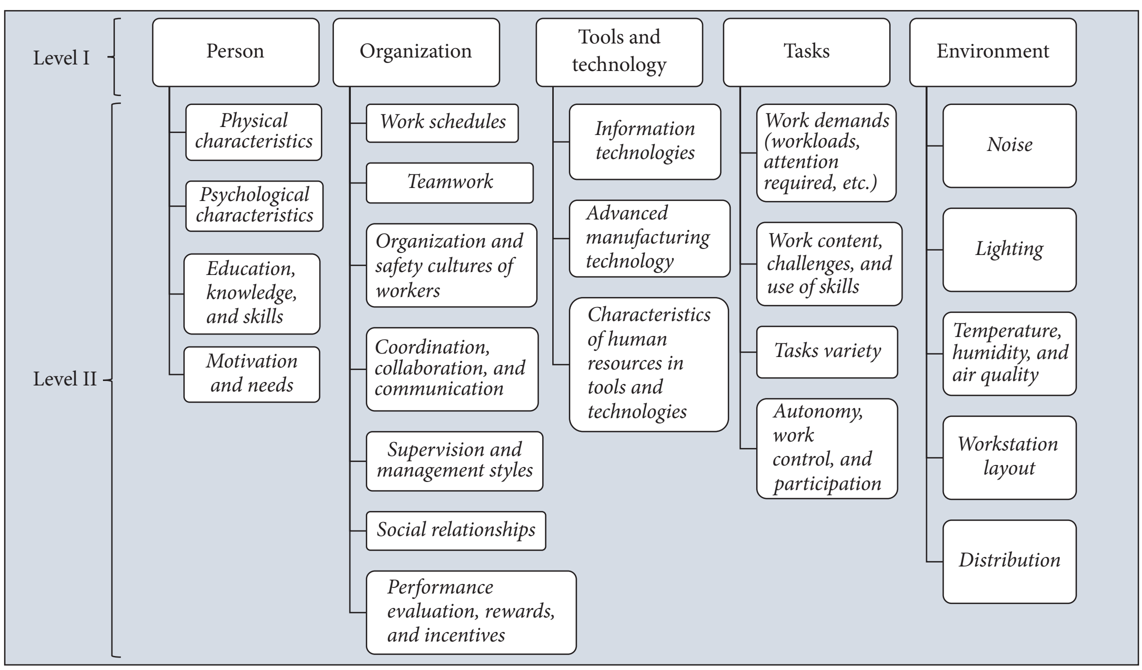

Figure 2: Macroergonomic factors and elements.

macroergonomic factors, elements, and the whole manufacturing system. The proposed method has nine stages as shown in Figure 3.

3.2.1. Stage 1: Administer the MCQ. The MCQ-WV sample included industrial and manufacturing engineers, managers, supervisors, and group leaders. The administration procedure was as follows:

(1) The National Institute of Statistics, Geography and Informatics (INEGI) and the Civil Association of Maquiladoras (AMAC, INDEX JUÁREZ) shared their databases with us to reach the manufacturing companies located in Ciudad Juárez. The databases included contact information (i.e., telephone number, e-mail, and address) of each company.

(2) This information was used to contact one top manager per manufacturing system. Every company manager was informed of the project and its benefits.

(3) The managers informed middle and senior managers about the project. After more than 30 middle and senior managers in a company accepted to participate, a meeting was scheduled to administer the MCQ.

As for the MCQ-EV, the sample included a group of ergonomics experts who were cautiously selected based on

Table 1: Sample of the MCQ-WV and the MCQ-EV.

MCQ-WV sample					
Macroergonomic practices	Perception levels				
	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
The company regularly evaluates employee performance.	1	2	3	4	5
The company considers human and ergonomic aspects when purchasing new information technology.	1	2	3	4	5
The company motivates its employees to do their best.	1	2	3	4	5
The work to be done depends on different information technologies.	1	2	3	4	5
Employees are explained how to use information technologies.	1	2	3	4	5
The tasks performed with information technologies are completed in risk-safe environments.	1	2	3	4	5
The salary is proportional to what employees do.	1	2	3	4	5
MCQ-EV sample					
Elements on which MPs are applied	Importance levels				
	Not important	Slightly important	Moderately important	Important	Highly important
Employee autonomy, job control, and participation	1	2	3	4	5
Lighting	1	2	3	4	5
Plant distribution	1	2	3	4	5
Noise	1	2	3	4	5
Temperature, humidity, and air quality	1	2	3	4	5
Workstation layout	1	2	3	4	5
Work demands (workload, mental effort, required attention, etc.)	1	2	3	4	5

Table 2: Characteristics of the experts sample.

Characteristics	E1	E2	E3	E4	E5	E6
Certification in ergonomics	*	*	*	*	*	*
Graduate studies	*	*	*	*	*	
Experience in manufacturing industries	*	*	*	*	*	*
Occupational health	*	*	*		*	*
Member of national ergonomics organizations	*	*	*	*	*	*
Member of international ergonomics organizations	*	*			*	
Publications in journals or congresses	*	*	*	*	*	*
Field experience (in years)	22	18	30	23	16	15

E = ergonomics expert.

their knowledge in ergonomics. We performed a careful revision of their résumés, certifications in ergonomics, professional background, and expertise. All the selected experts were invited via e-mail or phone to participate in the research, and those who voluntarily accepted answered the MCQ-EV by e-mail. Table 2 shows the characteristics of the experts sample.

3.2.2. Stage 2: Define the Ideal Solution (IS) for MCI. Since the MCI is based on dimensional analysis (DA), it relies on an ideal solution (IS) [2]. The IS is obtained from the scale of the MCQ-WV, in which the ideal answer is Totally Agree. In other words, the IS of the MCI of the macroergonomic elements is the full consensus from workers regarding a constant implementation of MPs in the company. Hence, IS is expressed by (1) as follows:

$$\text{IS} = \text{Totally Agree}. \qquad (1)$$

3.2.3. Stage 3: Data Defuzzification. The answers from the MCQ-WV are translated to a fuzzy scale to measure the degree of MPs implementation in the company. As for the MCQ-EV, a different fuzzy scale is employed to assess the level of importance (weights) of the MPs in every

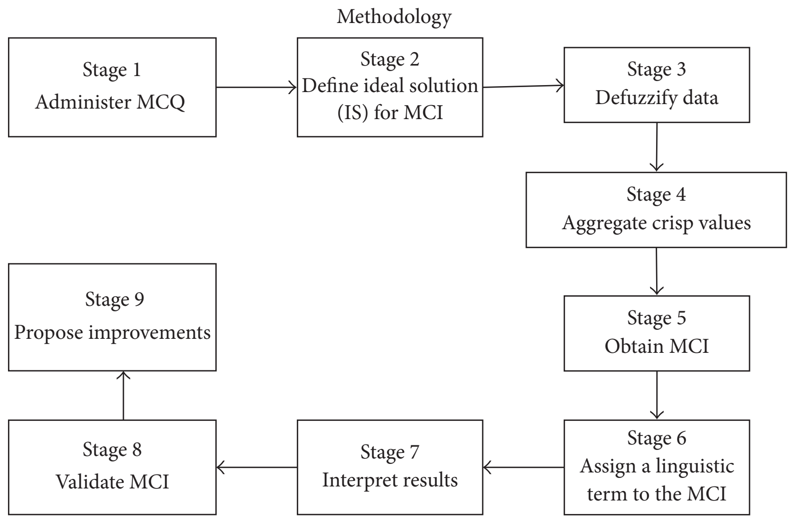

Figure 3: MCI calculation methodology.

macroergonomic element. In both questionnaires, the data are collected through an ordinal Likert scale in the form of triangular fuzzy numbers (TFNs). A TFN is a triplet (a, b, c), whose membership function $\mu_X(x)$ is defined as shown in the following equation [34]:

$$\mu_X(x) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \leq x \leq b \\ \dfrac{c-x}{c-b}, & b \leq x \leq c \\ 0, & x > c. \end{cases} \tag{2}$$

Then, the TFNs are converted to crisps numbers. To perform this conversion, we apply the center of area (CoA) technique, which, in a simplified way, defuzzifies a triangular fuzzy number $X = (a, b, c)$ by means of the following equation [35]:

$$x^* = \frac{(a+b+c)}{3}, \tag{3}$$

where x^* = crisp value of TFN X.

When (3) is applied for the ideal solution (IS), we obtain the following: IS $= (0.8 + 1 + 1)/3 = 0.93$. The same procedure must be followed with all the fuzzy values of Table 3 to calculate their corresponding crisp values, also shown in Table 3. This IS value is always used to calculate the MCI of the macroergonomic elements. Once each element has its corresponding MCI, the MCI of each macroergonomic factor and manufacturing system must be obtained with IS $= 1$, since the ideal solution of the MCI of the macroergonomic elements and factors is 1.

Once the data are defuzzified, they can be used as continuous data to perform the subsequent algorithms.

3.2.4. Stage 4: Aggregate Crisp Values. According to Lin et al. [36] and Realyvásquez-Vargas et al. [2], the arithmetic mean operation is the most widespread method for aggregating crisp data. The MCI relies on the arithmetic mean to aggregate crisp values as follows: if there are m surveyed workers for the MCQ-WV, from each worker i, a crisp value $x^*_{i,j}$ is obtained as the punctuation that refers to the degree of implementation of MP_j, $j = 0, 1, 2, \ldots, k$. Then, the average crisp punctuation $\overline{x}^*_j$ for MP_j is calculated by means of the following equation [2]:

$$\overline{x}^*_j = \frac{x^*_{1,j} + x^*_{2,j} + \cdots + x^*_{m,j}}{m}. \tag{4}$$

The MCI of a macroergonomic element e depends on the average crisp punctuation of specific MPs. Therefore, the values $\overline{x}^*_j$ obtained from (4) are used to calculate the MCI of the macroergonomic elements. The same procedure is applied to aggregate the weights provided by the experts and to obtain the average crisp weight $\overline{w}^*_l$ for macroergonomic element l. Then, the $\overline{w}^*_l$ values are used to calculate the MCI of the macroergonomic elements.

Table 3: Correspondence among linguistic terms, fuzzy numbers, and crisp numbers for the MCQ-WV and MCQ-EV scales.

Data	Type	Fuzzy number	Crisp number
	MCQ-WV		
Totally disagree	Punctuation	(0, 0, 0.4)	0.13
Strongly disagree	Punctuation	(0.2, 0.4, 0.6)	0.4
Neutral	Punctuation	(0.4, 0.6, 0.8)	0.6
Strongly agree	Punctuation	(0.6, 0.8, 1)	0.8
Totally agree	Punctuation	(0.8, 1, 1)	0.93
	MCQ-EV		
Very low	Weighting	(0, 0, 0.3)	0.1
Low	Weighting	(0, 0.25, 0.5)	0.25
Medium	Weighting	(0.3, 0.5, 0.7)	0.5
High	Weighting	(0.5, 0.75, 1)	0.75
Very high	Weighting	(0.7, 1, 1)	0.9

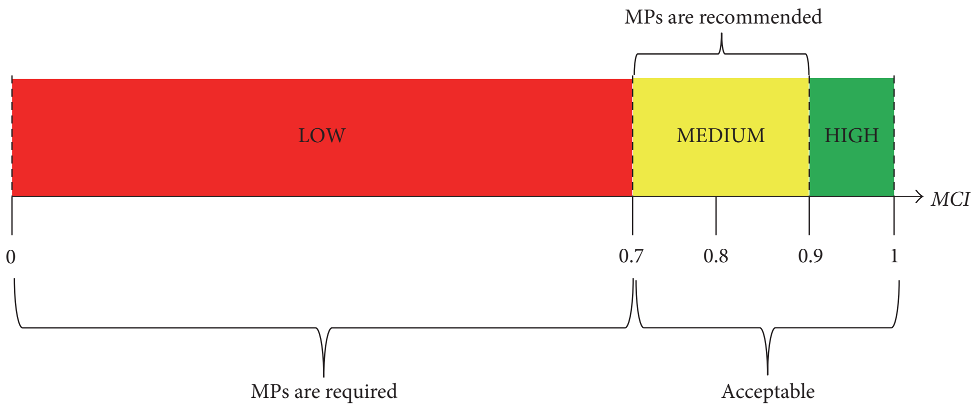

Figure 4: MCI scale.

3.2.5. Stage 5: Apply the Macroergonomic Compatibility Index (MCI). As mentioned above, the obtained crisp values $\overline{x}_j^*$ and $\overline{w}_l^*$ and IS = 0.93 are used to develop the MCI. Therefore, a dimensional analysis (DA) is conducted to measure the index, which is expressed by the following equation [2]:

$$\text{MCI} = \sqrt[W]{\prod_{i=1}^{n} \left[\frac{\overline{x}_j^*}{\text{IS}_i} \right]^{\overline{w}_l^*}}, \quad (5)$$

where $\overline{w}_l^*$ is weight of a macroergonomic element or factor l, n is number of ergonomics experts, and $W = \sum_1^n \overline{w}_l^*$.

It is important to mention that because the MCI of the macroergonomic elements depends on unweighted items, the weight of an element is used to obtain its MCI. This implies that, for a macroergonomic element, $W = \overline{w}_l^*$. On the other hand, for each macroergonomic factor, W is the sum of the weights of its macroergonomic elements, while in the case of a manufacturing system, W is the sum of the weights of all the macroergonomic factors. Therefore, to calculate the MCI of the macroergonomic factors and the manufacturing company or manufacturing system, we use (6), where IS = 1 [2].

$$\text{MCI} = \sqrt[W]{\prod_{i=1}^{n} \left[\overline{x}_j^* \right]^{\overline{w}_l^*}}. \quad (6)$$

According to several studies, ergonomic compatibility has a positive impact on manufacturing systems [37]. In other words, the higher the MCI, the better the element, the factor, or the manufacturing system.

3.2.6. Stage 6: Assign a Linguistic Term to the MCI. The MCI provides a scale of macroergonomic compatibility levels. This scale ranges from 0 to 1, and it is divided into three sections. The first section includes $0 \leq \text{MCI} \leq 0.70$, the second section refers to $0.70 < \text{MCI} \leq 0.90$, and, finally, the third section includes $0.90 < \text{MCI} \leq 1$. In every section, the MCI is related to a linguistic term. For the first section, the linguistic term is LOW, and it indicates that MPs are required. For the second section, the corresponding linguistic term is MEDIUM and indicates that MPs are optional. Finally, the linguistic term of the third section is HIGH and confirms that MPs are unnecessary. The macroergonomic compatibility scale is useful to detect the MFEs that require MPs according to their MCI value. Figure 4 shows this scale.

3.2.7. Stage 7: Interpret Results. The results must be analyzed and interpreted to formulate, first, a conclusion for each macroergonomic factor and element and, second, a conclusion regarding the overall macroergonomic compatibility of the manufacturing system. The interpretation of the results reveals which MFEs must be prioritized to receive macroergonomic interventions (i.e., MPs). Certainly, the MFEs to be prioritized have the lowest MCI values.

3.2.8. Stage 8: Validate the MCI. The goal of validating the MCI was to show the reliability and objectivity of the MCI methodology. That said, the validation process included three stages: validate the MCQ, validate the macroergonomic compatibility construct, and validate the MCI. To validate the MCQ, we conducted a factor analysis, and to validate the macroergonomic compatibility construct, we developed structural equation models (SEM) in five case studies, including this one. Finally, to test the validity of the MCI, we relied on data gathered from the MCQ-WV regarding the status of manufacturing companies in terms of costumers, manufacturing processes, and organizational performance. This set of parameters is known as benefits.

Then, the manufacturing systems were ranked in a descending order based on their MCI values. To validate the MCI, the manufacturing systems with higher MCI values should be those that also have better benefits in terms of clients, manufacturing process, and organizational performance [38]. Since the benefits do not affect the MCI, we used the average technique to aggregate the benefits data [36]. That said, it was not necessary to defuzzify the data. In the case of health and safety results, the fewer occupational accidents, injuries, and diseases are, the more compatible a company is. In this case, we performed another ranking of the companies, this time based on the reported accidents, injuries, and diseases. To validate the MCI, the companies with higher MCI values should be those with the best healthy and safety scores.

Table 4: MCI of MFEs.

MFEs	MCI	Linguistic term
Person	*0.328*	*LOW*
Education, knowledge, and skills	0.709	MEDIUM
Physical characteristics	0.413	LOW
Motivation and needs	0.316	LOW
Psychological characteristics	0.108	LOW
Organization	*0.214*	*LOW*
Supervision and management styles	0.529	LOW
Coordination, collaboration, and communication	0.352	LOW
Teamwork	0.294	LOW
Organization and safety cultures of workers	0.193	LOW
Social relationships	0.131	LOW
Work schedules	0.117	LOW
Performance evaluation, rewards, and incentives	0.107	LOW
Technology and tools	*0.198*	*LOW*
Characteristics of human resources in technology and tools	0.475	LOW
Advanced manufacturing technology	0.164	LOW
Information technologies	0.11	LOW
Tasks	*0.266*	*LOW*
Work content, challenges, use of skills	0.566	LOW
Tasks variety	0.429	LOW
Autonomy, work control, and participation	0.225	LOW
Work demands (workload, attention required, etc.)	0.092	LOW
Environment	*0.302*	*LOW*
Lighting	0.664	LOW
Noise	0.524	LOW
Temperature, humidity, and air quality	0.279	LOW
Distribution	0.188	LOW
Workstation layout	0.136	LOW
MCI of the manufacturing system	0.257	LOW

3.2.9. Stage 9: Propose Improvements. Improvement proposals should be formulated based on the MCI results and include applying macroergonomic or microergonomic methods in a specific macroergonomic factor or element, applying a method that is effective for all the macroergonomic elements and factors, and implementing new strategies in different areas.

4. Results and Discussion

4.1. MCI of the Case Study. The MCQ-WV was administered to 30 middle and senior managers from a manufacturing system located in Ciudad Juárez, Mexico, whereas the MCQ-EV was answered by six experts in ergonomics. Table 4 shows the MCI values, or the level of macroergonomic compatibility, of each macroergonomic factor and element. Also, the table shows the overall level of macroergonomic compatibility of the manufacturing system.

Note that almost all the macroergonomic elements showed a low level of macroergonomic compatibility. Only macroergonomic elements *Education, Knowledge, and Skills* showed a medium level of macroergonomic compatibility, since MCI = 0.709. The MCI value of this macroergonomic element demonstrates that the manufacturing company satisfactorily assigns employees tasks based on their educational level, skills, and knowledge, and it promotes education and knowledge/skills acquisition.

The results also revealed that the company rarely implements MPs, which is an obstacle to obtaining the benefits of appropriate macroergonomic compatibility. That said, ergonomic interventions are an area of opportunity in this plant. In this sense, and according to the MCI values presented in Table 4, the company must prioritize the implementation of macroergonomic practices in the following elements: *work demands (workload, attention required, etc.)*; *performance evaluation, rewards, and incentives*; *employee psychological characteristics*; *information technologies*; and *work schedules*. Finally, the results demonstrated that the overall macroergonomic compatibility of the company is low, since MCI = 0.257.

4.2. Validating the MCI. The validation results of the MCQ can be consulted in [33, 39], whereas the validation results of the macroergonomic compatibility construct are reported in [37, 39]. Similarly, the validity results of the MCI are shown in Table 5. The first column of the table shows the company

Table 5: Validation of the MCI.

Manufacturing system	MCI	Benefits: Customers	Manufacturing processes	Organizational performance	Average	Safety and health
1	0.4	4.14	3.43	3.88	3.82	0
2	0.362	4.04	3.44	4	3.83	0
3	0.313	3.68	3.15	3.81	3.55	0
4	0.268	3.82	3.22	3.56	3.53	0.67
5*	0.257	4.01	2.59	3.86	3.49	1492.33

*Manufacturing system studied in this article.

ranking based on the obtained MCI values (i.e., 1, 2, 3, 4, and 5), while the sixth column sets the company ranking based on benefits of company (i.e., 2, 1, 3, 4, and 5). Note that only two manufacturing systems (1 and 2) switch ranks, and only manufacturing systems 4 and 5 reported occupational accidents, injuries, or diseases, with system 5 being the one with the highest value in that category. Based on such results, we conclude that the MCI has enough validity.

4.3. Improvement Proposals. For the MFEs that require ergonomic interventions through MPs, we recommend the following:

(i) Reviewing the data collected from the MCQ-WV and the MCQ-EV to identify the MPs that need to be implemented

(ii) Developing strategies and actions to immediately implement the necessary MPs

(iii) Forming an ergonomics committee to ensure and supervise MPs implementation in every macroergonomic element. The committee should include one leader per macroergonomic factor and a top team leader

(iv) Designing a thorough work plan to list the macroergonomic compatibility goals to be reached and the tasks to be completed to reach such goals. The plan must include time and dates

(v) Consulting Stanton et al. [40] to educate the company on macroergonomic methods applicable to the manufacturing industry

5. Conclusions

The MCQ and the MCI are notable advances in ergonomics. In its three versions, the MCQ is a reliable instrument that simplifies and expedites the process of collecting macroergonomic compatibility data of various types. On the other hand, the MCI is a valid methodology for measuring the macroergonomic compatibility of both MFEs and an entire work system. Additionally, the MCI is a support tool for managers, ergonomists, medical experts, designers, and engineers to identify performance improvement opportunities at all hierarchical levels from a macroergonomic compatibility approach. In other words, the MCI methodology paves the way for new perspectives of company performance evaluation.

As for the MCI results, this research found that the surveyed company relies little on an ergonomic approach to work system design/redesign and organization. That said, ergonomic interventions in the form of MPs can help the company reach an appropriate level of macroergonomic compatibility and acquire another competitive strategy. For instance, the MCI results showed a medium level of macroergonomic compatibility of *Education, Knowledge, and Skills*. Such results imply that the company usually takes into account employee educational characteristics and abilities when assigning workers a particular job; however, the results also indicate that the company rarely considers other aspects, such as employee physical characteristics and work experience.

As regards recommendations for further research, we suggest spreading the use of the MCQ and the implementation of the MCI in other manufacturing companies and industrial sectors. That said, adaptations might be necessary in the three versions of the MCQ for the survey to fit in other research contexts and increase its validity.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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