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Effects of employees' physical and psychological characteristics over manufacturing systems' performance

Efectos de las características físicas y psicológicas de los empleados en el desempeño de los sistemas de manufactura

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ABSTRACT

One of the main challenges in Macroergonomics is to develop a universal model to measure macroergonomic compatibility. As a first step to develop such model, it is necessary to validate the construct of macroergonomic compatibility (MC). MC refers to the ability of the different work system components and elements to complement the capabilities and limitations of employees in order to achieve companies' goals. In that regard, to achieve this step, this paper analyzes the effects of MC of physical and psychological characteristics of employees over the performance of manufacturing systems measured by the *clients*, *production processes*, and the *organizational performance of companies*. Data was obtained from 188 employees of manufacturing systems by means of the Macroergonomic Compatibility Questionnaire (MCQ) in Chihuahua, Mexico. Also, data is analyzed to propose and test a hypothetical causal model of the relationships among the variables by using a Structural Equation Modeling (SEM) approach. Employees' *physical characteristics* (*weight*, *height*, *strength*) are considered as independent variable. The highest direct effects values (ß) were found from *physical characteristics* to *psychological characteristics* (0,49), from *clients* to *organizational performance* (0,45), and from *psychological characteristics* to *motivation and needs*. Also, the highest total effects were found from *physical characteristics* to *motivation and needs* (0,517) and *psychological characteristics* (0,488) and from *clients* to *organizational performance* (0,454). Results of this model offer relevant knowledge to develop macroergonomic strategies for manufacturing systems in order to increase their competitiveness and support the design and improvement of these systems.

Keywords: Macroergonomics, employees' characteristics, Macroergonomic Compatibility Questionnaire, Structural Equations Modeling, manufacturing systems.

RESUMEN

Uno de los principales desafíos en Macroergonomía es desarrollar un modelo universal para medir la compatibilidad macroergonómica (CM). Como primer paso para desarrollar dicho modelo, es necesario validar el constructo de CM. CM se refiere a la capacidad de los elementos y componentes de un sistema de trabajo de considerar y complementar las capacidades y limitaciones de los empleados para así, alcanzar los objetivos de las compañías. En este sentido, este artículo analiza los efectos de las características físicas y psicológicas de los empleados sobre el desempeño de los sistemas de manufactura medidos mediante los *clientes*, *procesos de producción*, y el *desempeño organizacional* de la empresa. Los datos se obtuvieron de 188 empleados de sistemas de manufactura mediante el Cuestionario de Compatibilidad Macroergonómica (CCM), en el Estado de Chihuahua, México. El análisis de los datos se realiza para proponer y probar un modelo hipotético causal de las relaciones entre las variables a través de un Modelo de Ecuaciones Estructurales (MES). Las *características físicas* (*peso*, *estatura*, *fuerza*) son consideradas como variables independientes. Los mayores efectos directos fueron de las *Características* físicas sobre las *Características psicológicas* (0,49), de los *clientes* sobre el *desempeño organizacional* (0,45), y de las *características psicológicas* sobre la *motivación y necesidades de los empleados*. Los mayores efectos totales fueron de las *características físicas* sobre *motivación y necesidades* (0,517) y sobre *características psicológicas* (0,488), y de la variable *clientes* sobre el *desempeño organizacional* (0,454). Esto genera conocimiento relevante para el desarrollo de estrategias macroergonómicas que permitan incrementar la competitividad de los sistemas de manufactura y apoyar y mejorar el diseño de estos sistemas.

Palabras clave: Macroergonomía, características de los empleados, Cuestionario de Compatibilidad Macroergonómica (CCM), Modelo de Ecuaciones Estructurales, sistemas de manufactura.

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Introduction

Macroergonomics is the ergonomics of work systems design (Domingues, Sampaio, & Arezes, 2012), and it aims to restructure the work system as a whole to increase safety, comfort, quality of life and system efficiency (organizational performance) (Silva, Nickel, & dos Santos, 2017). Then, in an increasingly saturated market place, competitiveness of manufacturing systems should be partly guided by an exhaustive analysis of macroergonomic compatibility of factors, such as employees' characteristics, organizational issues, tools and technology, tasks, and environmental conditions. Ergonomic compatibility considers the concepts of human–system and human–artefact compatibility introduced by (Karwowski, 1997, 2001). These concepts emerged from the need of having comprehensive treatment of compatibility in the human factor discipline (Maldonado, García, Alvarado, & Balderrama, 2013). Several authors such as Haro & Kleiner (2008), Karwowski (1997, 2000, 2001) Lange-Morales, Röbig and Bruder, 2011 and Maldonado *et al*. (2013) have discussed ergonomic compatibility either at micro- or macroergonomic level. According to Realyvásquez, Maldonado-Macías, García-Alcaraz, Cortés-Robles and Blanco-Fernández (2016), macroergonomic compatibility refers to the extent to which different macroergonomic factors and elements positively interact with humans to help work systems achieve their goals. Moreover, Lange-Morales, Röbig and Bruder (2011) point out that macroergonomic compatibility exists when a work system supports an appropriate interaction between the personnel and the technological subsystems, including the work systems' relationship with external environment characteristics.

Macroergonomic compatibility can bring benefits for manufacturing systems, including process optimization, reduction of occupational risks, and a notable improvement of life quality at work (García-Acosta & Lange-Morales, 2008; Haro & Kleiner, 2008). The correct design of a work system will determine its effectiveness (Kleiner, 2006; Pasmore, 1988). This paper designed and validated a new Macroergonomic Compatibility Questionnaire (MCQ) for manufacturing systems. This questionnaire was based on the Systems Engineering Initiative for Patient Safety (SEIPS) model, since its flexibility allows its application in all kinds of work systems (Carayon *et al*., 2006; Carayon *et al*., 2014). Also, this model provides the macroergonomic factors and elements needed to design work systems and the elements on which these have an impact. In work systems design, the term "employees" refers to the individuals who perform a range of tasks using tools and technologies (Carayon *et al*., 2006).

It has been stated that the lack of a universal matrix for measuring macroergonomic compatibility represents an obstacle in demonstrate the value of Ergonomics as a science and profession (Karwowski, 2006). Then the objective of this paper is to validate the construct of macroergonomic compatibility of *physical characteristics* and *psychological characteristics* of employees demonstrating that it has positive effects on manufacturing systems *clients*, *production processes*, and *organizational performance*. This objective represents a specific step of an original research which has the general objective of developing a mathematical model to measure macroergonomic compatibility of manufacturing systems. It is necessary to state that in this research, when authors discuss the physical and psychological characteristics of employees, they are stressing the appropriateness of these characteristics to a certain task.

The proposed hypothetical causal model

This paper examined the effects of some selected elements related to the employees (Carayon *et al*., 2006; Holden *et al*., 2013; Realyvásquez, García-Alcaraz, & Blanco-Fernández, 2016) to determine dependence relationships with the performance of manufacturing systems. Such performance was measured in terms of *clients*, *production processes*, and the *organizational performance*. Authors performed an extensive literature review, inclusive in some journals dedicated to ergonomics and/or manufacturing systems and they found that very few or no studies about these relations in manufacturing systems have been found so far. This represents a gap that may be covered by this research, at least on the sample studied. However, similar studies in some other work systems or areas of knowledge helped establish the hypotheses for this work.

Some studies of the variables and their relationships are given as an introduction to the hypothetical causal model. For instance, García-Alcaraz, Adarme-Jaimes and Blanco-Fernández (2016) found that some employees' characteristics (education and skills, human resources availability, and managerial commitment) have positive effects on quality of products, supply chain flexibility and economic performance in winery companies. However, their discoveries did not take a macroergonomic perspective as it is in this research.

From a macroergonomic perspective, and according to several authors, the element of *Psychological characteristics* (distress, stress, and depression)(American Psychiatric Association, 2014) refers to those individual characteristics that give the employee a perception of the work environment (Kruzich, Mienko, & Courtney, 2014). Previous studies revealed that human *Psychological characteristics* can be influenced by the element of *physical characteristics* (i.e. weight, height, strength, etc.) (Baumeister & Leary, 1995; O'Grady, 1989). For instance, Tsaousis and Nikolaou (2005) carried out a study with adults and found that there was a positive relationship between emotional intelligence (EI) and a better physical and psychological health functioning. More specifically, authors discovered that EI was negatively linked to the frequency of smoking and drinking, and positively connected to life quality.

On other study, Salem *et al*. (2008) measured the work compatibility of different work-related variables, including physical task, which intrinsically includes *physical characteristics* of employees. Their study group included 147 construction workers. As a result, they found that physical task was related to stress symptoms.

However, no hypothesis has yet been formulated to explain the relation between the *physical characteristics* and the *psychological characteristics* of employees in manufacturing systems from a macroergonomic perspective. Therefore, this paper proposes the following first hypothesis (H_1):

H_1: *Physical characteristics* of employees have a direct and positive effect on their *psychological characteristics* in manufacturing systems.

Another of the elements included in the SEIPS model is *motivation and needs*. Motivation is a construct that pertains whenever an activity is done in order to attain an outcome (Ryan & Deci, 2000), whereas need is defined as a state of perceived lack (Abarca-Morán, 2013). Several studies affirm a relation between the elements of *physical characteristics* and *motivation and needs* of employees, which include further financial reward, job security, communication in the workplace, free time, etc. (Hitka & Balážová, 2015). For instance, Seghers, Vissers, Rutten, Decroos, and Boen (2014) found that *physical characteristics* of children have an impact on their physical goals (e.g. leisure-time sport and physical activity). Similarly, Baena-Extremera, Gómez-López, Granero-Gallegos, and Abraldes (2014) found that *motivation and needs* impact more on boys than on girls as far as physical education is concerned. Finally, Owen, Smith, Lubans, Ng and Lonsdale (2014) also found that there was a positive relationship between *motivation and needs* and the physical activity in children and adolescents. However, few studies contextualize the existing relationship between *physical characteristics* and *motivation and needs* of employees in manufacturing systems. Thus, this paper proposes hypothesis H_2 from a macroergonomic approach:

H_2: *Physical characteristics* of employees have a direct and positive effect on their *motivation and needs* in manufacturing systems.

As for the relation between *psychological characteristics* and *motivation and needs*, May, Gilson and Harter (2004) demonstrated that there is a connection between these two elements. These authors found that the *psychological characteristics* increased motivation of employees regarding their commitment to work. In addition, Realyvásquez, Maldonado-Macías, García-Alcaraz, Cortés-Robles, *et al*. (2016)a new macroergonomic compatibility questionnaire (MCQ discovered that macroergonomic compatibility of *psychological characteristics* has a direct and positive effect on employees' performance in manufacturing systems. Then, we assume that with a better performance, motivation increases. Based on this, this paper formulates a third hypothesis (H_3) from a macroergonomic approach:

H_3: *Psychological characteristics* of employees have a direct and positive effect on their *motivation and needs* in manufacturing systems.

Also, some authors (Domingues, Sampaio, & Arezes, 2016) support the last two hypotheses by pointing out that macroergonomic practices increases employees' motivation.

Psychological characteristics are critical for personal success, but they are also an essential part for the success of a company. For instance, in a descriptive model Etgar (2008)1 states that *psychological characteristics* of customers can help improve the *production processes (*complaints from *clients*, defects, inventory level and productivity, goods, and service) (Chen, Shie, & Yu, 2012; Ismail, 2007), resulting in improved *organizational performance* for the company. Also, as mentioned above, Realyvásquez, Maldonado-Macías, García-Alcaraz, Cortés-Robles, *et al*. (2016)a new macroergonomic compatibility questionnaire (MCQ found that psychological characteristics has a positive effect on employees' performance in manufacturing systems, which will positively impact on the production processes. Therefore, based on these arguments and the model of (Etgar, 2008)e, this paper proposes the following hypothesis that relates the *psychological characteristics* of employees with the *production processes* of manufacturing systems:

H_4: *Psychological characteristics* of employees have a direct and positive effect on the *production processes* of manufacturing systems.

According to Luneburg and Susman (2005), a client is "any person or entity that employs or retains another person for financial or another compensation to conduct lobbying activities on behalf of that person or entity". In this research, *clients* involve aspects such as the number of *clients* of the company and their loyalty. Also, as Realyvásquez, Maldonado-Macías, García-Alcaraz, Cortés-Robles, *et al*. (2016)a new macroergonomic compatibility questionnaire (MCQ found that *psychological characteristics* have positive effects on employees' performance in manufacturing systems, this paper proposed hypothesis H_5:

H_5: *Psychological characteristics* of employees have a direct and positive effect on the *clients* of manufacturing systems.

Motivation and needs are employees' characteristics that may impact on *clients* of manufacturing systems. Even though literature on this matter is scarce, Winefield and Barlow (1995) found a positive relationship between the *motivation and needs* of employees of a child protection agency and the *clients* of the agency. In another study, Phillips and Bourne (2008) found a significant relationship between the employees' personal values and the *clients'* outcomes in the treatment of substance misuse. Based on this background, authors of this paper propose hypothesis H_6:

H_6: *Motivation and needs* of employees have a direct and positive effect on *clients* of manufacturing systems.

Organizational performance is another complex and multidimensional variable. In this research, *organizational performance* is based on the number of employees of the manufacturing system (Melián-González & Bulchand-Gidumal, 2016), the variety of products (Ismail, 2007), and turnover (Armstrong & Baron, 2002). In fact, the implementation of *motivation and needs* in the *production process* helps improve *organizational performance* (Hitka & Balážová, 2015). Based on this fact, and on the relation of *motivation and needs* with *clients*, we propose that the former variable has an impact on the organizational performance of companies. Thus, H_7 and H_8 can be proposed from a macroergonomic approach:

H_7: *Motivational and needs* of employees have a direct and positive effect on the *production processes* of manufacturing systems.

H_8: *Motivation and needs* of employees have a direct and positive effect on the *organizational performance* of manufacturing systems.

Nowadays, *clients* play a key role in the competitiveness of all companies. For example, Alden, Hoa, and Bhawuk (2004) found that there was a positive relation between clients' satisfaction of a clinic and the future visits to that clinic. These future visits helped the clinic maintain competitive advantage. Also, Junquera, del Brío, and Fernández (2012) discovered that when clients were involved in environmental issues and organizational performance in manufacturing systems, they had a positive impact on that business' competitiveness. More recently, Realyvásquez, Maldonado-Macías, García-Alcaraz, Gómez-BullandBlanco-Fernández (2016) found that loyal and satisfied *clients* have a direct and positive effect on the *organizational performance* of manufacturing systems. In order to provide more evidence of the effects of clients on manufacturing systems, and based on these findings, this paper proposes the following hypothesis (H_9) for manufacturing systems in the context of Macroergonomics:

H_9: *Clients* of manufacturing systems have a direct and positive effect on the *organizational performance* of manufacturing systems.

Regarding the effect of production processes on the organizational performance of manufacturing systems, Lagacé and Bourgault (2003) point out that processes of manufacturing systems are a key condition to ensure long-term sustainability. Also, Realyvásquez, Maldonado-Macías, García-Alcaraz, Gómez-Bull, *et al*. (2016) found that reliability of production processes impacts positively on the organizational performance of manufacturing systems. Based on these researches, this paper proposes the following hypothesis for manufacturing systems from a macroergonomic perspective:

H_{10}: *Production processes* of manufacturing systems have a direct and positive effect on the *organizational performance* of manufacturing systems.

Figure 1 depicts the proposed hypothetical causal model. In figures and tables *Pc = physical characteristics, Psyc = psychological characteristics, Mn = motivation and needs, C = clients, Pp = production processes,* and *Op = organizational performance*.

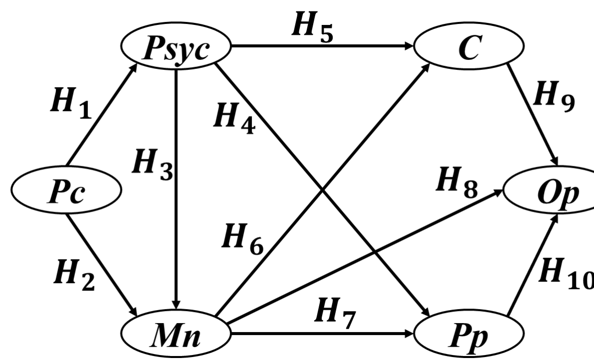

Figure 1. Proposed Hypothetical Causal Model.
Source: Authors

Methodology

Development of the Macroergonomic Compatibility Questionnaire (MCQ)

Literature presents several macroergonomic methods (e.g. interview, focus groups, participatory ergonomics, laboratory experiment, macroergonomic analysis of structure [MAS], macroergonomic analysis and design [MEAD], etc.), which help identify some problems of work system design (Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2004). However, none of these methods involves a macroergonomic compatibility measurement or index (MCI) or can relate macroergonomic variables of compatibility with manufacturing systems (in terms of the *clients*, *production processes,* and *organizational performance*).

Based on this background, the MCQ is developed in order to measure macroergonomic compatibility of manufacturing systems. It contains 138 items divided into four sections, each of them concerning one of the following types of information: 1) demographic data (6 items), 2) extent to which employees agree that their company applies specific macroergonomic practices (92 items), 3) the frequency at which companies apply such macroergonomic practices (22 items), and 4) the extent to which companies benefit from the application of macroergonomic practices (18 items). This research focuses only on sections 2 and 4.

MCQ is applied to manufacturing systems located in Chihuahua, Mexico. During the administration of the MCQ a control group collects the data. Participants are employees of middle and senior management, since they possess a more complete vision of the work performed in the companies where they work, their deficiencies, and the opportunities for improvement. And also, managers showed resistance to operators answer the MCQ, since they considered it has so many and this would take so much time for stopping manufacturing process. The sample of the MCQ used for this research (sections 2 and 4) is showed in Table A.1 in the Appendix A. Note that the MCQ is answered with a 5-point fuzzy Likert scale, where 1) Totally disagree, 2) Very disagree, 3) neither agree nor disagree, 4) Very agree, and 5) Totally agree. We used the convenience method as sample method due to its high feasibility and low cost (Guo *et al*., 2011). Convenience method is a no probabilistic sampling method basically consisting of people readily available to researchers (Ozdemir, St Louis, & Topbaş, 2011).

Statistical analysis of data

MCQ statistical validation: Statistical validation of MCQ is performed using the SPSS® software. The Cronbach's Alpha index is used for every dimension, considering a minimum cutoff value of 0,7 units (García, Maldonado, Alvarado, & Rivera, 2014). Variables with Cronbach's Alpha values lower than 0,7 are removed. The average variance extracted (AVE) and the cross-factor loadings are used as indicators of discriminant and convergent validity. As far as convergent validity is concerned, a minimum value of 0,5 is recommended for every item, while the P value has to be significant (García *et al*., 2014; Kock, 2013).

The index of variance inflation factors (VIFs) is used to detect collinearity between latent variables. However, the condition is that the VIF value in every dimension or latent variable must be lower than 3,3 (García *et al*., 2014). Since data are presented in an ordinal scale, the coefficient of Q-squared is used as a nonparametric measure of predictive validity. High reliability is achieved when Q-squared value is greater than zero (García *et al*., 2014; Kock, 2013).

Analysis of structural equation model: Structural equation modeling (SEM) is considered the most suitable technique to perform the analysis of relationships among variables when it includes several independent and dependent variables (García *et al*., 2014). In this study, only the variable *physical characteristics* is considered as independent, while all other variables are dependent. This is shown in Figure 1.

The analysis among relationships in Figure 1 is performed with the aid of the WarpPLS4® software, which does not use a conventional "linear" regression algorithm, but a sophisticated algorithm based on partial least squares (PLS) to analyze data. This allows for the management of non-linear models (Kock, 2013; Ockert, 2014). Also, this research does not provide fit indexes such as chi-squared, root mean square error of approximation (RMSEA), and goodness of fit index (GFI), since they are irrelevant for this research (Ockert, 2014). Moreover, WarpPLS4® software is widely recommended for small-sized samples (García *et al*., 2014; Kock, 2013).

The model fit indices used to evaluate the model are average path coefficient (APC), average R-squared (ARS), and average variance inflation factor (AVIF). For the APC and ARS, the general criterion to accept or reject a relationship is the P value. Since this inference analysis is made by using a confidence interval of 95%, relationships with a $P < 0,05$ are considered significant; otherwise, they are insignificant and must be removed (Angarita, Niño, Vargas, Hernández, & Torres, 2017; Gaona, Sánchez-Alonso, & Montenegro, 2014). Once all the relationships are significant, authors analyze the load values. If one variable shows a higher load value in any dimension different from the one to which it belongs, this variable is then removed. Value 5 was the maximum acceptable value for the AVIF (García *et al*., 2014; Kock, 2013).

The measurement of direct effects (García *et al*., 2014) is used in order to validate the hypotheses depicted in Figure 1, since direct effects indicate a direct relation among dimensions. However, indirect effects are also measured. The sum of direct and indirect effects equals the total effects.

Results

This research was performed in transnational manufacturing companies located in Ciudad Juárez, Chihuahua. The research comprised a sample of five manufacturing companies and a total of 188 employees of middle and senior management. Five surveyed companies belong to the automotive sector. Manufacturing company 1 manufactures internal combustion engines, turbines, transmissions, unit injectors, railway systems, and electronic modules. This company employs around 1 450 workers. Similarly, manufacturing company 2 makes electronic filter assemblies and offers products such as filters, sensors, connectors, potentiometers, and amplifiers, among others. This company employs 352 people.

Respect manufacturing company 3, it is an electromechanical manufacturer, and it produces accessories for vehicles such as windshield wipers; it employs 1 367 workers. In the case of manufacturing company 4, it is a global leading manufacturer of electric motors, electrical motion controls, power generation and power transmission products serving markets throughout the world. The surveyed plant employs around 2 500 people. Finally, manufacturing company 5 is of one of the world's most appreciated automotive leather suppliers. The plant employs around 2 200 employees.

Statistical analysis of data

MCQ statistical validation: MCQ was administered in manufacturing systems in the State of Chihuahua, Mexico with 188 participants. It was properly validated using the Cronbach Alpha index and factor analysis.

As for the model fit and quality indices, both APC and ARS showed values of 0,313 and 0,312 respectively. Moreover, the P values were lower than 0,001. Therefore, the relationships shown in Figure 1 are significant. Moreover, the value obtained for the Tenenhaus GoF (GoF) was 0,448, which confirm that the model as a whole possesses a large overall explanatory power and predictive quality (Kock, 2013). Reliability of MCQ was high, since the Cronbach's Alpha value was higher than 0,7 in all the analyzed dimensions. In addition, all the AVE values were greater than the minimum cutoff value 0,5. Then, the survey has discriminant and convergent validity. All R-squared values were acceptable for dependent latent variables, since they were higher than 0,02. Finally, all Q-squared value for each dependent variable demonstrated to be greater than zero. Thus, the nonparametric predictive validation is high.

Effects among variables

Direct and indirect effects: Figure 2 presents the direct effects, which quantify the sensitivity of a dependent latent variable to changes in an independent latent variable, while all other variables in the analysis remain fixed (Pearl, 2001). The values expressed in β are dependence measurement values and represented standardized values. P values stand for the values of the significance hypotheses tests. Also, WarpPLS used a significance level of 0,05; hence, since all relations had a P value lower than 0,05, they are significant.

According to Figure 2, the most significant direct effects were from *physical characteristics* to *psychological characteristics* and *motivation and needs*, and from *clients* to *organizational performance*. Indirect effects occur between dimensions and through other dimensions and emerge from the relation of several segments (García *et al*., 2014). Table 1 shows the sum of indirect effects between latent variables analyzed. Note that all the indirect effects among latent variables were significant, yet the most significant effects were from *psychological characteristics* to *organizational performance* and from *physical characteristics* to *clients*.

Total effects: Total effects are defined as the sum of total direct and indirect effects (Garcia *et al*., 2014). Table 2 shows the total effects among the dimensions analyzed.

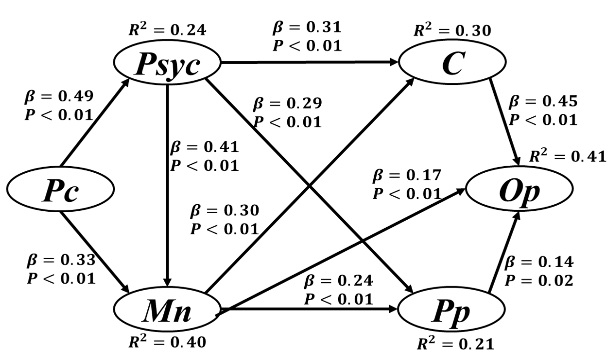

Figure 2. Direct Effects.
Source: Authors

Table 1. Sum of Indirect Effects

To	From		
	Pc	*Psyc*	*Mn*
Mn	0,198*		
C	0,314*	0,123**	
Pp	0,266*	0,093**	
Op	0,268*	0,319*	0,170**

*Significant at 99,9%, **Significant at 98%
Source: Authors

Table 2. Total Effects

To	From				
	Pc	*Psyc*	*Mn*	*C*	*Pp*
Psyc	0,49*				
Mn	0,528*	0,41*			
C	0,314*	0,433*	0,30*		
Pp	0,266*	0,383*	0,24*		
Op	0,268*	0,319*	0,34*	0,45*	0,14**

*Significant at 99,9%, **Significant at 98%
Source: Authors

The most significant total effects were from *physical characteristics* to *motivation and needs*, and from *physical characteristics* to *psychological characteristics*. These two variables and *motivation and needs* had significant effects over *clients* and *organizational performance* of manufacturing systems. However, variable *clients* showed the major effect on *organizational performance*. This demonstrates that *clients* have an important effect over the competitiveness of manufacturing systems.

As to the sample size, and according to Kock and Hadaya (2018), two methods to estimate the minimum sample size of a SEM are the 10-times rule method, and the minimum *R*-squared method. These authors state that the 10-times rule is the most widely used minimum sample size estimation method in SEM. This method stablishes the rules that the minimum sample size should be greater than 10 times the maximum inner or outer model's links pointing at any latent variable in the model. In the model presented in this research, the maximum inner or outer model's links pointing at any latent variable is 3; then, the minimum sample size required, according to this method, is 30, but it was 188.

Respect the minimum *R*-squared method, it considers three elements: 1) the maximum number of arrows pointing at any latent variable in the model, 2) the significance level, and 3) the minimum R^2 in the model. According to (Kock & Hadaya, 2018), for a maximum of 3 arrows pointing at any latent variable (as in this research), combined with a minimum R^2 = 0,10, the minimum sample size required is 124; whereas with a minimum R^2 = 0,25, the minimum sample size required is 59. Then it can be stated that in this research, with a minimum R^2 = 0,21, the minimum sample size required could be 124; however, it was 188. Therefore, the sample size requirement is met.

Respect to results from the application of the MCI, Table 3 shows the results of the global MCI of the case studies of applying this MCI in the five manufacturing companies. For more detailed results of MCI respect macroergonomic elements and factors, consult (Realyvásquez-Vargas, Maldonado-Macías, & García-Alcaraz, 2018; Realyvásquez & Maldonado-Macías, 2018; Realyvásquez, Maldonado-Macías, García-Alcaraz, & Arana, 2018).

Table 3. MCI of manufacturing companies

Manufacturing company	MCI
1	0,401
2	0,368
3	0,322
4	0,269
5	0,257

Source: Authors

Macroergonomic practices can be considered as a preventive action that minimizes the microergonomic interventions, since Macroergonomics has a potential as a feasible excellence implementation system strategy (Domingues *et al.*, 2012).

Discussion

Although Ergonomics research is evolving, the knowledge on practical cases is still scarce on manufacturing industry in Mexico. One of the main causes of this lack of knowledge is, in part, the resistance of managers to participate in research. This resistance may lead to obtain and analyze data that sometimes are imprecise at some extent, since researcher cannot have a complete and extensive view of current situation on workplaces and the perceptions of most of the employees, especially operators. Additionally, the effects of *physical characteristics* and *psychological characteristics* of employees are misestimated and neglected during the design and implementation of manufacturing systems and consequently over their performance. This highlights the need to promote ergonomics and its benefits, conduct research and implement it in systems manufacturing in Mexico.

Currently, in Mexico, the Ministry of Labor and Social Security (Secretaría del Trabajo y Previsión Social, STPS) is carrying a project to implement some official mexican norms (Normas Oficiales Mexicanas, NOMs) that consider ergonomic and psychosocial aspects in all work centers. Then, results of this research can serve as scientific basis for managers of manufacturing companies to understand that considering physical and psychological characteristics of employees helps improve their wellbeing and occupational performance. Also, if managers keep motivated their employees, this will lead manufacturing companies to meet the NOMs and to improve their organizational performance.

The findings of this research offer new knowledge about the effects of employees' characteristics and the impact over manufacturing systems performance. As the objective of this paper was validate the construct of macroergonomic compatibility of *physical characteristics*, *psychological characteristics*, and *motivation and needs* of employees, and through the methodology applied and the results obtained it can be seen that this research has positively impacted on Macroergonomics evolution in terms of formality as a subdiscipline, and so Ergonomics. This evolution is mainly on the goal of develop, validate and unify a universal matrix to measure macroergonomic compatibility. The evolution may entail the development, validity and application of a macroergonomic compatibility questionnaire, and the validity of macroergonomic compatibility as a construct.

Conclusions

According to the results presented in Figure 2, Table 1, and Table 2, *physical* and *psychological characteristics* of employees are important variables for the competitiveness of manufacturing systems in Chihuahua, México. *Physical characteristics* possess significant direct, indirect, and total effects over almost all other variables. Similarly, *psychological characteristics* have the major direct effects over *motivation and needs*, *clients*, and *production processes*; the highest indirect over *organizational performance*; and the highest total effect over *clients* and *production processes*.

As for the dependent variables, *clients* has the highest direct and total effects on *organizational performance* and *production processe*s of manufacturing systems. This means that manufacturing systems must pay special attention to these variables in order to increase their competitiveness.

According to results in Figure 2, the following conclusions can be drawn:

Macroergonomic compatibility of *physical characteristics* has positive direct effects over macroergonomic compatibility of *psychological characteristics* in employees of manufacturing systems (H_1).

Macroergonomic compatibility of *physical characteristics* and *psychological characteristics* have positive direct effects over macroergonomic compatibility of *motivation and needs* among the employees of manufacturing systems (H_2 and H_3).

Macroergonomic compatibility of *psychological characteristics* and *motivation and needs* have positive direct effects over *clients* (H_5 and H_6).

Macroergonomic compatibility of *psychological characteristics* and *motivation and needs* have positive direct effects over *production processes* of manufacturing systems (H_4 and H_7).

Macroergonomic compatibility of *motivation and needs* of employees, satisfaction of *clients* and efficient *production processes* have positive direct effects over *organizational performance* of manufacturing systems (H_8, H_9 and H_{10}).

Regarding the hypotheses stated in section 2, it is concluded that there is not enough statistical evidence to reject any of them. This is summarized in Table 4. Then it is concluded that the proposed model has been validated for manufacturing systems from the analyzed sample.

Table 4. Conclusion about the hypotheses

To	From				
	Pc	*Psyc*	*Mn*	*C*	*Pp*
Psyc	Not rejected H_1				
Mn	Not rejected H_2	Not rejected H_3			
C		Not rejected H_5	Not rejected H_6		
Pp		Not rejected H_4	Not rejected H_7		
Op			Not rejected H_8	Not rejected H_9	Not rejected H_{10}

Source: Authors

Specifically in this research, authors achieve the objective of determining the effects (direct, indirect and total) of macroergonomic compatibility of specific macroergonomic elements (physical characteristics, psychological characteristics, and motivation and needs) on clients, production systems and organizational performance of manufacturing systems. This represents a contribution to one of the steps for developing the macroergonomic compatibility universal matrix, at least on the manufacturing sector.

Methodology presented here is original, since it related macroergonomic compatibility of employees' characteristics to manufacturing systems in terms of *clients, production processes,* and *organizational performance*. It is important to point out that these employees' characteristics are only some of the macroergonomic elements mentioned in literature. As for the MCQ, it is concluded that it is a new and effective instrument to collect information about macroergonomic practices and the frequency of their application in manufacturing systems. This can also help measure macroergonomic compatibility of these systems by means of statistical or mathematical methods.

However, still there are some lacking steps to develop a universal matrix to measure and quantify macroergonomic compatibility, such steps may include 1) determine the effects of macroergonomic compatibility of others macroergonomic elements on the same and in different populations of the presented in this paper, 2) the development of a mathematical model that helps know the macroergonomic compatibility level of each macroergonomic factor, element and the general macroergonomic level of the company; and 3) develop a software that facilitates the calculation of macroergonomic compatibility.

As it is known, results were obtained from transnational companies which had several plants in Mexico and around the world. So, the results can be valid and reliable at national level based on the premise that all plants of the same company apply the same macroergonomic practices. However, to ensure validity and reliability at international level, case studies must be performed in different contexts around the world.

Recommendations and future research

According to results obtained in this research, macroergonomic factors of manufacturing systems have direct and indirect effects on the performance of these work systems. Thus, a successful performance can also provide long-term benefits.

Also, results from this study may encourage companies to consider a macroergonomic perspective in the design of a work system. Similarly, researchers may direct their efforts towards the development of effective and efficient indexes to measure macroergonomic compatibility of manufacturing systems. Results of this research have also confirmed that satisfied *clients* represent a competitive advantage for manufacturing firms. Finally, results have also suggested that the application of micro- and macroergonomic practices within manufacturing systems need to be promoted in order to gain competitiveness and achieve positive outcomes.

Researchers are advised to expand macroergonomic research to other fields, such as education and construction systems, among others. However, such research must be focused not only on the application of macroergonomic practices, but also on the development of comparative analyses of the outcomes that companies can obtain. Authors of this paper also recommend continuing searching for an effective index (mathematical model) to measure ergonomic compatibility of manufacturing systems and other work systems.

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References

Abarca-Morán, G. (2013). ¿Cuál es el aporte al Emprendedurismo Social de las Asociaciones Solidarista en Costa Rica? Análisis del Modelo de Armonía Obrero-Patronal y Marco Jurídico que las faculta al otorgamiento de dicho aporte

Alden, D., Hoa, D., & Bhawuk, D. (2004). Client satisfaction with reproductive health-care quality: integrating business approaches to modeling and measurement. *Social science & medicine*, 59(11), 2219-2232.

American Psychiatric Association. (2014). *Actualización de la Codificación del DSM-5. Suplemento del Manual Diagnóstico y Estadístico de Trastornos Mentales* (5th ed.). Airlington, VA.

Angarita, H., Niño, P., Vargas, D., Hernández, N., & Torres, A. (2017). Identifying explanatory variables of structural state for optimum asset management of urban drainage networks: a pilot study for the city of Bogota. *Ingeniería e Investigación, 37*(2), 6–16. DOI: 10.15446/ing.investig.v37n2.57752

Armstrong, Michael, & Baron, Angela. (2002). Strategic HRM: The key to improved business performance: CIPD Publishing.

Baena-Extremera, A., Gómez-López, M., Granero-Gallegos, A., & Abraldes, J. A. (2014). Motivation, Motivational Climate and Importance of Physical Education. *Procedia - Social and Behavioral Sciences, 132*(0), 37-42. DOI: 10.1016/j.sbspro.2014.04.275

Baumeister, R.F., & Leary, M.R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological bulletin, 117*(3), 497.

Carayon, P., Hundt, A.S., Karsh, B.T., Gurses, A.P., Alvarado, C.J., Smith, M., & Brennan, P. (2006). Work system design for patient safety: the SEIPS model. *Quality and Safety in Health Care, 15*(suppl 1), i50-i58.

Carayon, P., Wetterneck, T. B., Rivera-Rodriguez, A. J., Hundt, A. S., Hoonakker, P., Holden, R., & Gurses, A. P. (2014). Human factors systems approach to healthcare quality and patient safety. *Appl Ergon, 45*(1), 14-25. DOI: 10.1016/j.apergo.2013.04.023

Chen, C.K., Shie, A.J., & Yu, C.H. (2012). A customer-oriented organisational diagnostic model based on data mining of customer-complaint databases. *Expert Systems with Applications, 39*(1), 786-792. DOI: 10.1016/j.eswa.2011.07.074

Domingues, P., Sampaio, P., & Arezes, P. M. (2012). New organisational issues and macroergonomics : integrating management systems. *Int J Human Factors and Ergonomics, 1*(4), 351–375. DOI: 10.1504/IJHFE.2012.052009

Domingues, P., Sampaio, P., & Arezes, P. M. (2016). Integrated management systems assessment: a maturity model proposal. *Journal of Cleaner Production*, *124*, 164–174. DOI: 10.1016/j.jclepro.2016.02.103

Etgar, M. (2008). A descriptive model of the consumer co-production process. *Journal of the academy of marketing science*, *36*(1), 97-108.

Gaona, P. A., Sánchez-Alonso, S., & Montenegro, C. E. (2014). Visualization of information: a proposal to improve the search and access to digital resources in repositories. *Ingeniería e Investigación*, *34*(1), 83–89. DOI: 10.15446/ing.investig.v34n1.39449

García-Acosta, G., & Lange-Morales, K. (2008). Macroergonomic study of food sector company distribution centres. *Applied Ergonomics, 39*(4), 439-449. DOI: 10.1016/j.apergo.2008.02.004

García-Alcaraz, J.L., Adarme-Jaimes, W., & Blanco-Fernández, J. (2016). Impact of human resources on wine supply chain flexibility, quality, and economic performance. *Ingeniería e Investigación*. *36*(3), 74-81. DOI: 10.15446/ing.investig.v36n3.56091

García, J.L., Maldonado, Aidé Aracely, Alvarado, A., & Rivera, D.G. (2014). Human critical success factors for kaizen and its impacts in industrial performance. *The International Journal of Advanced Manufacturing Technology*, 70(9-12), 2187-2198.

Guo, Y., Li, X., Fang, X., Lin, X., Song, Y., Jiang, S., & Stanton, B. (2011). A comparison of four sampling methods among men having sex with men in China: implications for HIV/STD surveillance and prevention. *AIDS Care, 23*(11), 1400–14009. DOI: 10.1080/09540121.2011.565029

Haro, E., & Kleiner, M.B. (2008). Macroergonomics as an organizing process for systems safety. *Applied Ergonomics*, 39(4), 450-458. DOI: 10.1016/j.apergo.2008.02.018

Hitka, Miloš, & Balážová, Žaneta. (2015). Comparison of Motivation Level of Service Sector Employees in the Regions of Slovakia and Austria. *Procedia Economics and Finance*, *23*, 348-355. DOI: 10.1016/S2212-5671(15)00393-7

Holden, R., Carayon, P., Gurses, A., Hoonakker, P., Hundt, A., Ozok, A., & Rivera-Rodriguez, A. J. (2013). SEIPS 2.0: A human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics, 56*(11), 1–30. DOI: 10.1080/00140139.2013.838643

Ismail, R. B. (2007). Implementations Problems in Lean Manufacturing: A study in manufacturing industries. (Bachelor of Manufacturing), Malaysia Technical University of Melaka, Malaysia.

Junquera, B., del Brío, J.A., & Fernández, E. (2012). Clients' involvement in environmental issues and organizational performance in businesses: an empirical analysis. *Journal of Cleaner Production*, 37, 288-298.

Karwowski, W. (1997). Ancient wisdom and future technology: the old tradition and the new science of human factors/ergonomics. Paper presented at the Proceedings of the Human Factors and Ergonomics Society 4th Annual Meeting, Albuquerque, NM, Human Factors and Ergonomics Society, Santa Monica, Ca.

Karwowski, W. (2000). Symvatology: The science of an artifact-human compatibility. *Theoretical Issues in Ergonomics Science*, *1*(1), 76-91.

Karwowski, W. (2001). *International encyclopedia of ergonomics and human factors* (Vol. 3): Crc Press.

Karwowski, W. (2006). Symvatology: The science of an artifact-human compatibility. In *International encyclopedia* *of ergonomics and human factors* (2nd ed., pp. 206–211). Boca Raton: Taylor & Francis.

Kleiner, M.B. (2006). Macroergonomics: Analysis and design of work systems. *Applied Ergonomics*, *37*(1), 81-89. DOI: 10.1016/j.apergo.2005.07.006

Kock, N. (2013). WarpPLS© 3.0 user manual. ScriptWarp Systems™. Laredo, TX, USA.

Kock, N., & Hadaya, P. (2018). Minimum sample size estimation in PLS-SEM: The inverse square root and gamma-exponential methods. *Information Systems Journal*, *28*(1), 227–261. DOI: 10.1111/isj.12131

Kruzich, J.M., Mienko, J.A., & Courtney, M.E. (2014). Individual and work group influences on turnover intention among public child welfare workers: The effects of work group psychological safety. *Children and Youth Services Review, 42*(0), 20-27. DOI: 10.1016/j.childyouth.2014.03.005

Lagacé, D., & Bourgault, M. (2003). Linking manufacturing improvement programs to the competitive priorities of Canadian SMEs. *Technovation, 23*(8), 705-715.

Lange-Morales, K., Röbig, S., & Bruder, R. (2011). Compatibility in multiplicity: Towards a complex understanding of medical devices use. In S. Albolino, S. Bagnara, T. Bellandi, J. Llaneza, G. Rosal, & R. Tartaglia (Eds.), *Healthcare Systems Ergonomics and Patient Safety* (pp. 334–337). London, UK: Taylor & Francis Group.

Luneburg, W.V., & Susman, T.M. (2005). The Lobbying Manual: A Complete Guide to Federal Law Governing Lawyers and Lobbyists: American Bar Association.

Maldonado, Aidé Aracely, García, J.L., Alvarado, A., & Balderrama, C.O. (2013). A hierarchical fuzzy axiomatic design methodology for ergonomic compatibility evaluation of advanced manufacturing technology. *The International Journal of Advanced Manufacturing Technology*, 66(1-4), 171-186.

May, D.R., Gilson, R.L., & Harter, L.M. (2004). The psychological conditions of meaningfulness, safety and availability and the engagement of the human spirit at work. *Journal of occupational and organizational psychology*, 77(1), 11-37.

Melián-González, Santiago, & Bulchand-Gidumal, Jacques. (2016). A model that connects information technology and hotel performance. *Tourism Management, 53*, 30-37.

O'Grady, K.E. (1989). Physical attractiveness, need for approval, social self-esteem, and maladjustment. *Journal of Social and Clinical Psychology*, *8*(1), 62-69.

Ockert, D. (2014). Japanese JHS students' Ideal L2 Selves: Confidence, anxiety, and willingness to communicate. In B. Bailey (Ed.), *The Language Teacher* (Vol. 38, pp. 61). Tokyo: JALT Publications.

Owen, K.B., Smith, J., Lubans, D.R., Ng, J.Y.Y., & Lonsdale, C. (2014). Self-Determined Motivation and Physical Activity in Children and Adolescents: A Systematic Review and Meta-Analysis. Preventive medicine.

Ozdemir, R. S., St Louis, K. O., & Topbaş, S. (2011). Public attitudes toward stuttering in Turkey: probability versus convenience sampling. *Journal of Fluency Disorders*, *36*(4), 262–267. DOI: 10.1016/j.jfludis.2011.01.003

Pasmore, W.A. (1988). Designing effective organizations: The sociotechnical systems perspective.

Pearl, J. (2001). Direct and indirect effects. Paper presented at the Proceedings of the seventeenth conference on uncertainty in artificial intelligence.

Phillips, R., & Bourne, H. (2008). The impact of worker values on client outcomes within a drug treatment service. *International Journal of Drug Policy*, *19*(1), 33-41. DOI: 10.1016/j.drugpo.2007.11.012

Realyvásquez, A., García-Alcaraz, J. L., & Blanco-Fernández, J. (2016). Desarrollo y validación de un cuestionario de compatibilidad macroergonómica. *Contaduría Y Administración*, *61*(3), 478–498. DOI: 10.1016/j.cya.2016.04.002

Realyvásquez, A., & Maldonado-Macías, A. A. (2018). Measuring the Complex Construct of Macroergonomic Compatibility: A Manufacturing System Case Study. *Complexity*, *2018*, 1–10. DOI: 10.1155/2018/7374307

Realyvásquez-Vargas, A., Maldonado-Macías, A., & García-Alcaraz, J. L. (2018). *Macroergonomics for Manufacturing Systems An Evaluation Approach*. (J. P. Davim, Ed.) (1st ed.). Cham, Switzerland: Springer International Publisher. DOI: 10.1007/978-3-319-68684-4

Realyvásquez, A., Maldonado-Macías, A.-A., García-Alcaraz, J.-L., Gómez-Bull, K.-G., & Blanco-Fernández, J. (2016). Effects of Macro-ergonomic Compatibility of Work Demands on Manufacturing Systems' Organizational Performance. In C. Schlick & S. Trzcieliński (Eds.), *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future. Proceedings of the AHFE 2016 International Conference on Human Aspects of Advanced Manufacturing*, July 27–31, 2016, Walt Disney World®, Florida, USA Conference (pp. 432–443). Wolt Disney World, FL.: Springer. DOI: 10.1007/978-3-319-41697-7_38

Realyvásquez, A., Maldonado-Macías, A., García-Alcaraz, J. L., & Arana, A. (2018). Macroergonomic Compatibility Index for Manufacturing Systems. A Case Study. In S. Trzcielinski (Ed.), *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future* (pp. 179–189). Los Ángeles, CA: Springer International Publishing. DOI: 10.1007/978-3-319-60474-9

Realyvásquez, A., Maldonado-Macías, A., García-Alcaraz, J., Cortés-Robles, G., & Blanco-Fernández, J. (2016). Structural Model for the Effects of Environmental Elements on the Psychological Characteristics and Performance of the Employees of Manufacturing Systems. *International Journal of Environmental Research and Public Health*, *13*(1), 1–21. DOI: 10.3390/ijerph13010104

Ryan, R., & Deci, E. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*, 54–67. DOI: 10.1006/ceps.1999.1020

Salem, O., Sobeih, T. M., Genaidy, A., Shell, R., Bhattacharya, A., & Succop, P. (2008). Work compatibility and musculoskeletal disorders in the construction industry. *Human Factors and Ergonomics in Manufacturing, 18*(2), 230–252. DOI: 10.1002/hfm.20110

Seghers, J., Vissers, N., Rutten, C., Decroos, S., & Boen, F. (2014). Intrinsic goals for leisure-time physical activity predict children's daily step counts through autonomous motivation. *Psychology of Sport and Exercise, 15*(3), 247-254. DOI: 10.1016/j.psychsport.2014.01.003

Silva, L. D., Nickel, E. M., & dos Santos, F. A. N. V. (2017). Evaluation of Macroergonomic Methods for the Application of Organization Analyzes in Startups. In F. Rebelo & M. Soares (Eds.), A*dvances in Ergonomics in Design: Proceedings of the AHFE 2017 International Conference on Ergonomics in Design* (pp. 329–339). Los Ángeles, CA: Springer.

Stanton, N.A., Hedge, A., Brookhuis, K., Salas, E., & Hendrick, H.W. (2004). *Handbook of human factors and ergonomics methods*: CRC Press.

Tsaousis, I., & Nikolaou, I. (2005). Exploring the relationship of emotional intelligence with physical and psychological health functioning. *Stress and Health, 21*(2), 77-86.

Winefield, H.R., & Barlow, J.A. (1995). Client and worker satisfaction in a child protection agency. *Child Abuse & Neglect, 19*(8), 897-905. DOI: 10.1016/0145-2134(95)00052-A

Appendix A

Table A.1. Macroergonomic Compatibility Questionnaire for the assessment of employees characteristics, *production processes*, *clients*, and *organizational performance*

In your company:	1	2	3	4	5
Physical characteristics					
Physical characteristics (weight, height, strength) of employees are considered for task allocation					
Employees receive attention when they present a physical discomfort					
Causes of employees' physical discomfort are analyzed					
Psychological characteristics					
Employees' psychological characteristics (distress, stress, depression, and satisfaction) are considered for task allocation					
Employees receive attention when they present a psychological discomfort such as mental stress, depression, etc.					
Causes of employees' psychological discomfort are analyzed					
Tasks are designed in order to avoid employees' psychological discomfort					
Tasks are designed to provide satisfaction to employees					
Motivation and needs					
Motivation and needs are taken into account for tasks allocation					
Employees are motivated to perform by means of problems' solutions					
Labor help is given to employee when he needs it					
There are promotions and labor growth opportunities					
Production processes					
The number of complaints by clients is very low					
The number of defects is very low					
Inventory levels are low					
Productivity has increased over the time					
Clients					
Needs and expectative of clients are considered					
Clients are satisfied with the products they receive					
Clients keep loyal with the company					
The number of clients has increased over the time					
Organizational performance					
Productivity has improved					
The number of employees has increased					
The variety of products has increased					
The business has improved					