



**UNIVERSIDAD AUTÓNOMA DEL ESTADO DE MÉXICO**

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FACULTAD DE INGENIERÍA

**“RED BAYESIANA PARA SELECCIONAR  
HERRAMIENTAS DE GESTIÓN DE MEJORAS PARA  
AUMENTAR LA SATISFACCIÓN DEL CLIENTE EN LA  
INDUSTRIA DE LA CONSTRUCCIÓN”**

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PRESENTA:

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## Resumen

El presente trabajo ha sido considerado para los gerentes y profesionales de la industria de la construcción; responsables de la dirección de proyectos, que estén encaminados en la mejora de la calidad de sus productos y servicios que a su vez se reflejan en la satisfacción del cliente.

En esta investigación presenta un modelo cualitativo con el uso de Redes Bayesianas (BN's) enfocado en medir la satisfacción del cliente, y el uso de las herramientas de gestión en el sector de la construcción ya que ha demostrado ser un importante determinante de la calidad. Se basa en los resultados de un estudio empírico previo, dentro de una muestra de cincuenta empresas mexicanas y el uso de un conjunto de más de treinta herramientas de gestión divididas en 5 grupos (1) recopilación de necesidades del cliente, (2) organización de las necesidades del cliente, (3) métodos formales, (4) herramientas de planificación, (5) control de calidad, (6) medidas de desempeño y (7) tecnología (Ver tabla 1). El primer conjunto está destinado a recopilar los deseos del cliente, el segundo está destinado a ordenar sus requisitos. Los llamados "métodos formales" son metodologías sistematizadas que pueden ayudar a construir productos de calidad. El grupo de planificación es útil para programar los recursos necesarios al inicio del proyecto. La unidad de "control de calidad" verifica el cumplimiento de las normas y los requisitos legales existentes. El grupo de "medidas de desempeño" considera el éxito de las iniciativas de calidad, y la "tecnología" incluye el uso de herramientas de software y hardware. Se propone una Red Bayesiana (BN) para seleccionarlos. El BN resultante consta de veinticuatro nodos y es útil para elegir algunas herramientas que ayuden a aumentar la satisfacción del cliente. Mediante el análisis de las variables objeto de estudio es posible establecer su interacción y dependencias.

De tal manera que esta investigación pretende dar como resultado una perspectiva acerca de los niveles esperados de satisfacción del cliente, incluso actualizar dichos niveles si se deseara implementar alguna herramienta de los diferentes grupos de gestión, ayudando a gerentes y profesionales de la industria de la construcción.

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## Recepción artículo

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## **Introducción**

A fines de 2018, los tres países de América del Norte firmaron el Acuerdo Estados Unidos-México-Canadá (USMCA). El objetivo principal del arreglo fue aprovechar un mercado combinado con casi 500 millones de personas, donde se alentarán las inversiones en empresas, instalaciones de producción y construcción (Oustr, 2020). Con estas ideas en mente, las empresas constructoras mexicanas ahora tienen la oportunidad de trabajar en uno de los mercados más grandes del mundo. Para hacerlo, deben asumir el liderazgo en los esfuerzos de mejora para eventualmente aumentar su competitividad e ingresos.

Tras una amplia revisión de la literatura, se ha reconocido una diversidad de herramientas, técnicas y métodos para mejorar la calidad. Se hizo evidente que las empresas a menudo luchan por identificar la más adecuada para ellas, debido a la gran cantidad de herramientas disponibles. Para avanzar en el uso de modelos cuantitativos en el campo de la gestión de la calidad y cerrar esta brecha en la literatura, se presentará una red bayesiana. Su construcción se ha basado en una encuesta realizada en México poco antes por Delgado-Hernández et al. (2017). Se cree que el caso de México podría ser de utilidad para los países de la región latinoamericana. Esto se debe a que la nación comparte con sus contrapartes un conjunto de características como el idioma, la cultura y la economía (WEF, 2019). En consecuencia, se cree que la importancia de la investigación para la industria de la construcción es relevante.

## **Antecedentes**

Se realizó un estudio por Cruz Cruz and Vences García (2015) el cual tenía por objetivo desarrollar un sistema experto para la selección de herramientas de gestión de calidad, con la finalidad de identificar la extensión de uso y la relevancia percibida de un conjunto de treinta herramientas de gestión en el Valle de Toluca y Ciudad de México CDMX (antes Distrito Federal). El sistema ayuda a la toma de decisiones con respecto a qué herramienta de gestión de calidad utilizar de acuerdo a la etapa de proyecto en la que se encuentran adicional a esto emite como resultado el nombre de la herramienta de gestión de calidad, adicional el sistema proporciona una breve descripción, en la que se explica en qué consiste dicha herramienta. Dicho estudio se llevó a cabo a través de un cuestionario (Anexo A), el cual está dividido en 4 secciones (1) Información general, (2) Iniciativas de Calidad, (3) Herramientas de Calidad y (4) Asuntos

Relacionados con la Calidad. Como resultado, 200 empresas del Valle de Toluca y CDMX, fueron seleccionadas de una base de datos con la que se contaba en la Facultad de Ingeniería de Universidad Autónoma del Estado de México, se recibieron 72 respuestas de las cuales solo 50 se pudieron emplear para el análisis, cabe mencionar que esa misma muestra se utilizó para el análisis de esta investigación.

### **Planteamiento del problema**

La literatura reporta diferentes enfoques. Rocha-Lona et al. (2013) desarrollaron una metodología para seleccionar métodos y herramientas en el entorno de gestión de la calidad. Los seis pasos involucrados fueron: (1) sistema de gestión de calidad y diagnóstico de procesos comerciales: alineación de un plan de acción y la planificación estratégica de la empresa, (2) selección de modelos, métodos y herramientas para determinar su idoneidad, (3) evaluación de la necesidad de aplicar las herramientas candidatas, (4) analizar los costos de implementación asociados, (5) revisar si la empresa tiene los recursos necesarios para ponerlos en práctica, y (6) examinar si la empresa es capaz de lograr sus objetivos de calidad mediante el uso de la herramientas. Al ser un enfoque cualitativo, puede ser útil en muchos sectores, no exclusivamente en la industria de la construcción. Como puede verse, los enfoques para seleccionar las herramientas han sido el foco de una amplia gama de investigaciones.

En particular en esta investigación se estudian los impactos que tienen los usos de las herramientas de gestión en la satisfacción del cliente, al mismo tiempo el modelo nos ayuda a predecir los porcentajes de satisfacción del cliente de la muestra original de 50 empresas del Valle de Toluca y CDMX.

### **Alcance y limitaciones**

Esta investigación se basa en los resultados de un estudio empírico previo sobre el uso, dentro de una muestra de 50 empresas mexicanas, de un conjunto de más de treinta herramientas. Luego propone una Red Bayesiana (BN) para seleccionarlos. Mediante el análisis de las variables objeto de estudio es posible establecer su interacción y dependencias. El BN resultante consta de veinticuatro nodos y es útil para elegir algunas herramientas que ayuden a aumentar la satisfacción del cliente. Esta investigación tiene como objetivo llenar este vacío en la literatura.

## **Hipótesis**

H0: Las empresas que usan herramientas para recolectar las necesidades de sus clientes, tienen mayor satisfacción que las que no lo hacen.

## **Objetivo**

El objetivo de esta investigación es presentar un modelo cualitativo con el uso de Redes Bayesianas (BN's) y la ayuda de herramientas de gestión, enfocado en medir la satisfacción del cliente en la industria de la construcción mexicana.

## **Metodología**

La literatura incluye una gran variedad de procedimientos y herramientas para evaluar la satisfacción del cliente, tales como: eventos de árbol, observaciones cuantitativas, análisis de probabilidad, juicio de expertos y BN's (Fatah et al., 2006), (Chakraborty et al., 2016), (Arinciheva et al., 2019). Hon et al. presentaron un análisis exhaustivo de la utilidad de los BN en el sector de la construcción. (2021). Informaron sobre aplicaciones relacionadas con la gestión de la seguridad, la gestión de riesgos, la gestión de contratos, el control de procesos, la gestión de costos de proyectos y la gestión de calidad. Un análisis exhaustivo informado por Weber et al. (2012). Destacaron su potencial para: modelar problemas complejos, realizar diagnósticos y predicciones, evaluar la probabilidad exacta de ocurrencia de un evento, incorporar información original, ofrecer un enfoque visual, fácil de usar y simple. Habiendo considerado estos beneficios, se concluyó que los BN eran apropiados para construir el modelo para seleccionar herramientas de gestión de mejora destinadas a aumentar la satisfacción del cliente

# **Bayesian Network for Selecting Improvement Management Tools to Increase Customer Satisfaction in the Construction Industry: Case Study of Mexico**

## **Abstract**

### **Purpose**

The use of improvement tools in the construction sector has shown to be an important determinant of quality. Companies endeavoring to enhance their daily practices require assistance, evidence, standards, frameworks, and quantitative models from existing experts to help them set out for the road. This paper is aimed to assist construction managers in the selection of tools to increase customer satisfaction.

### **Design/methodology/approach**

This piece of research is based on the results of a previous empirical study on the use, within a sample of Mexican firms, of a set of more than thirty tools. It then proposes a Bayesian Network (BN) to select them. By analyzing the variables under study, it is possible to establish their interaction and dependencies. The resultant BN comprises twenty-four nodes, and it is useful for choosing some tools that help to increase customer satisfaction.

### **Findings**

The overall results from the hypothetical scenarios explored were positive, reflecting the relevance of the proposed model.

### **Practical implications**

The BN can help practitioners in the global construction industry to improve their quality practices, to foster loyalty and to grow revenues.

### **Originality/value**

Most of the research reported in the area of continuous improvement in construction, focuses on qualitative considerations and it is still scarce in terms of developing mathematical models for selecting existing tools and, ultimately, satisfying customer's requirements. This investigation is aimed to bridge this gap in the literature.

Keywords: Bayesian Network, Improvement Management Tools, Total Quality Management (TQM), Mexico, Construction Projects

## **Introduction**

The top five sectors in the Mexican economy during 2020 were the manufacturing industry, the housing, the wholesale and the retail sectors, and the construction industry. Their combined contribution to the Gross Domestic Product (GDP) exceeded 50% (INEGI, 2021). Accordingly, firms attempting to improve their practices in both the housing and the construction marketplaces can be benefited from theoretical oriented research based on existing empirical information.

At the end of 2018, the three North American countries signed the United States–Mexico–Canada Agreement (USMCA). The main thrust of the arrangement was to take advantage of a combined market with almost 500 million people, where investments in enterprises, production facilities and construction will be encouraged (Oustr, 2020). With these ideas in mind, Mexican construction businesses now have the opportunity to work in one of the greatest markets in the world. To do so, they should assume the leadership in improvement efforts to eventually increase their competitiveness and revenue.

Following a broad review of the literature, a diversity of tools, techniques and methods to improve quality have been recognized. It became evident that companies often struggle to identify the most appropriate for them, due to the large number of tools available. Then, the main motivation for carrying out this investigation was the lack of systematic research to date to develop a

probabilistic mathematical model for selecting quality management tools in the construction sector, aimed at enhancing customer satisfaction.

To advance the use of quantitative models in the quality management arena and to bridge this gap in the literature, a Bayesian network will be presented. Its construction has been based on a postal survey conducted in Mexico a little while before by Delgado-Hernández, Cruz-Cruz, and Vences-García (2017). It is believed that the case of Mexico could be useful for countries in the Latin American region. This is because the nation shares a group of features with its counterparts such as language, culture and economies (WEF, 2019). Consequently, the significance of the research to the construction industry is thought to be relevant.

In the subsequent parts, a brief explanation of the Mexican construction context will be firstly offered. Then, the tools used in the previous survey will be highlighted. Next, the concepts behind BN's will be summarized, along with the variables included in the model. After that, the BN and its main characteristics will be discussed in combination with its real use and practical implications. Finally, the conclusions of the research will be established.

### **Mexican Construction Context**

The Global Competitiveness Index, as reported in the World Economic Forum (WEF, 2019), revealed that Mexico ranked 54th out of 141 countries for Infrastructure. The index takes into consideration characteristics such as road connectivity (22nd), quality of roads (49th), quality of railroad infrastructure (58th), quality of air transport infrastructure (80th), quality of electricity supply (81st) and mobile telephone subscriptions (112th). These rankings show that research in the construction quality management field is still required to improve the country's position.

Boadu, Wang, and Sunindijo (2020) have reported the challenges that the construction industry in developed nations, such as Mexico, face. They pinpointed fragile monitoring schemes, poor management commitments, absence of training, scarcity of procedures and incompetent

enforcement. Moreover, a study conducted by Aire and Aguilar (2021) in the Mexico City subway line 12, recently collapsed, discovered important variability in the materials' quality attributes. They went on to say that a new quality control system should be encouraged based on their observations. These ideas are in line with anecdotal evidence of the importance that contractors give to the bidding process, grounded on economic aspects, generally neglecting the relevance of quality and technical properties.

Unlike the manufacturing or automotive industries, construction deals with four uncertainties that make it different from other sectors. They are: natural (changing weather conditions), task (projects of varying complexity), organizational (different people each time) and contractual (particular obligations for each project) (Walker, 2015). Furthermore, professionals should interact with a variety of participants involved in the construction process like clients, specialists, contractors, regulatory authorities and suppliers. Subsequently, the utilization of management tools aimed at improving their practices would be highly recommended.

Again, while reviewing the literature, it became apparent that managers in the sector regularly struggle to select the best for them, because of the great number of tools available. Then, the emphasis of this piece of research will be on those for managing projects. The tools of interest are based on a preceding study (Delgado-Hernández et al., 2017), and will be revisited in the next section. But before presenting them, it is important to note that Mexico is currently building the following major projects: (1) Mexico City airport upgrading, (2) Toluca City airport improvement, (3) "Santa Lucia" Military Base conversion to a new international airport, (4) Mayan train, (5) "Dos Bocas" refinery, (6) Veracruz new port expansion, and (7) Itsmo de Tehuantepec's interoceanic corridor (Colunga & Mora-Ávila, 2021). As is evident from the list, construction specialists working on these projects need guidance to choose the right tools.

## Improvement Management Tools in Construction

As already stated, the categorization of tools presented by Delgado-Hernández et al. (2017) is adopted. Basically, seven groups are considered: (1) gathering customer needs, (2) organizing customer needs, (3) formal methods, (4) planning tools, (5) quality control, (6) performance measures and (7) technology (see Table 1). While the first set is intended to collect customer desires, the second is aimed at ordering their requirements. The so-called ‘formal methods’ are systematized methodologies that can help to build quality into products. The planning group is useful for scheduling the required resources at the start of the project. The ‘quality control’ unit verifies conformance to existing standards and legal requirements. The ‘performance measures’ cluster considers the success of quality initiatives, and ‘technology’ includes the use of both software and hardware tools. The rationale for this classification can be found elsewhere (Delgado-Hernández et al., 2017).

Group	Tools
Gathering customer needs	Customer surveys
	Customer one-to-one interview
	Customer telephone interview
	Brainstorming
	Focus groups
Organizing customer needs	Affinity diagram
	Tree diagram
	Matrix diagram
Formal methods	Quality function deployment (QFD)
	Theory of inventive problem solving (TRIZ)
	Concurrent engineering (CE)

<b>Group</b>	<b>Tools</b>
Planning tools	Mission statement
	Gantt chart
	Critical path method (CPM)
	Program evaluation and review technique (PERT)
	Teams & teamwork
Quality control	Laws and regulations
	Checklist
	Housekeeping (5Cs; also known as 5Ss)
	Inspection
	Sampling
	Quality audits
	Contractor partnerships
Performance measure	Customer satisfaction survey
	Customer complaints
	Litigation
	Departmental purpose analysis (DPA)
Technology	Planning software (e.g., Primavera, Microsoft Project)
	Design software (e.g., AutoCAD for Computer Aided Design)
	Finite element analysis software (e.g., SAP 2000 for Structural Analysis Program)
	Computer network (e.g., electronic mail)

Table 1. Improvement Management Tools for Increasing Customer Satisfaction (Adapted from:  
(Delgado-Hernández et al., 2017)

In terms of choosing them, the literature reports different approaches. Rocha-Lona, Garza-Reyes, and Kumar (2013) developed a methodology for selecting methods and tools in the quality

management environment. The six steps involved were: (1) quality management system and business processes diagnostic—alignment of both an action plan and the company’s strategic planning, (2) models, methods, and tools screening for suitability, (3) assessing the need of applying the candidate tools, (4) analyzing the associated implementation costs, (5) reviewing whether the firm has the necessary resources to put them into practice, and (6) examining whether the business is able to achieve its quality goals through the use of the tools. Being a qualitative approach, it can be useful in many sectors, not exclusively in the construction industry.

More recently, Voinov et al. (2018) carried out a comprehensive literature review, which yielded an overview of different selecting methodologies. In terms of the qualitative viewpoint, they reported: (1) rich pictures, (2) cognitive/concept mapping, (3) causal loop diagrams, (4) cultural consensus, and (5) decision tree analyses. Regarding the semi-quantitative angle, they included: (1) fuzzy cognitive mapping, (2) scenario building, (3) social network analysis, and (4) analytic hierarchy process. From the quantitative standpoint, they considered: (1) geographic information systems, (2) empirical modeling, (3) cost-benefit and other economic analyses, (4) system dynamics, (5) cellular automata, (6) agent based modeling, (7) integrated modeling and (8) Bayesian Networks (BN’s).

As can be seen, the approaches for selecting the tools have been the focus of a wide range of research. While the authors do not claim to be exhaustive in the review, the initiatives listed are enough to identify a variety of perspectives. Although all of them have been developed to select tools, the use of BN’s is still scarce in the construction management arena. As will be discussed later, they may be used not only with diagnostic but also with prognostic and predictive purposes. Therefore, there is a need to generate a Bayesian model aimed at predicting customer satisfaction through the selection of the appropriate improvement management tools.

The next section will present some of the BN's that have been employed in construction. Then, the considerations behind BN's will be recapitulated, along with the variables that will be included in the proposed model.

### **Bayesian Networks in the Construction Management Context**

The literature includes a great variety of procedures and tools to assess customer satisfaction, such as: tree events, quantitative observations, probability analysis, expert judgement and BN's (Fatah, Nauck, & Boettcher, 2006), (Chakraborty, Mengersen, Fidge, Ma, & Lassen, 2016), (Arinciheva, Arincieva, Matveeva, & Darmilova, 2019). Regarding the latter, a comprehensive analysis of the usefulness of BN's in the construction sector was presented by Hon et al. (2021). They reported applications related to safety management, risk management, contract management, process control, project cost management and quality management.

Just to name a couple of examples of the use of BN's for quality management in the sector, Yu et al. (2019) employed them to assess the impacts of quality faults in construction projects. Their study showed that the handling of precast elements with quality defects, poor maneuvering and poor-quality testing were the most influencing factors for low customer satisfaction. Moreover, Ji, Li, and AbouRizk (2019) proposed an information-based approach to quantify operator quality performance for specific pipes and welds. The research findings have shown that it has effectively helped the company to consolidate its quality management practices, increasing customer satisfaction. Again, the interested reader may consult Hon et al. (2021) for more examples. Having said this, now a brief description of what a BN is, will be presented.

A BN is a Directed Acyclic Graph (DAG). In general, it is a probabilistic graphical model that contains: (i) nodes representing random variables, and (ii) arcs, which help not only to connect nodes but they also imply relationships. The direct predecessors of a node are known as parents, and the direct successors are known as children (Hanea, Napoles, & Ababei, 2015). Moreover,

BN's represent the information about the joint probability of the nodes, expressed as local distributions for every variable conditional to its parents. Mathematically, the following expression summarizes the conditional probabilities within a BN:

$$P(x) = P(x_1, \dots, x_n) = \prod [P(x_i | p_{\alpha_i})] \quad (1)$$

Where  $p_{\alpha_i}$  is the numerical representation for the parents of  $X_i$ . BN's update the marginal distributions based on new information. A number of algorithms in BN's can be found to perform updating processes (Hanea et al., 2015). Even more, a comprehensive analysis of the usefulness of BN's was reported by Weber, Medina-Oliva, Simon, and Iung (2012). They highlighted their potential to: model complex issues, carry out both diagnostics and predictions, evaluate an event's exact occurrence probability, incorporate original information to update the model, characterize multi-modal variables, offer a visual, user-friendly and simple approach. Having considered these benefits, it was concluded that BN's were appropriate to build the model for selecting improvement management tools aimed at increasing customer satisfaction. In the subsequent section, the proposed BN will be presented.

### **The Proposed Bayesian Network**

The developed network comprises twenty-four nodes in total, divided into five categories: two company features, seven business activities, seven quality initiatives, seven management tools groups and the customers satisfaction node. The former encompasses the number of employees and the ISO 9001 certification nodes. Then, the BN considers seven activities: building, civil engineering, briefing, designing, tendering, construction and commissioning. Next, it includes the initiatives: quality department, cultural change programme, strategies for total quality, employee involvement to improve quality, employees' training, teams and individual recognition. The seven groups of management tools follow, i.e., gathering customer needs,

organizing customer needs, formal methods, planning and programming tools, quality control, performance measures and technology. Finally, the customer satisfaction node is taken into account. It is important to note that all twenty-four variables can only assume two states, in general zero for false and one for true. For example, if the ISO 9000 certification node is set to one, it means that the company under analysis has such a certificate. Figure 1 shows the resultant BN, its nodes and their relationships.

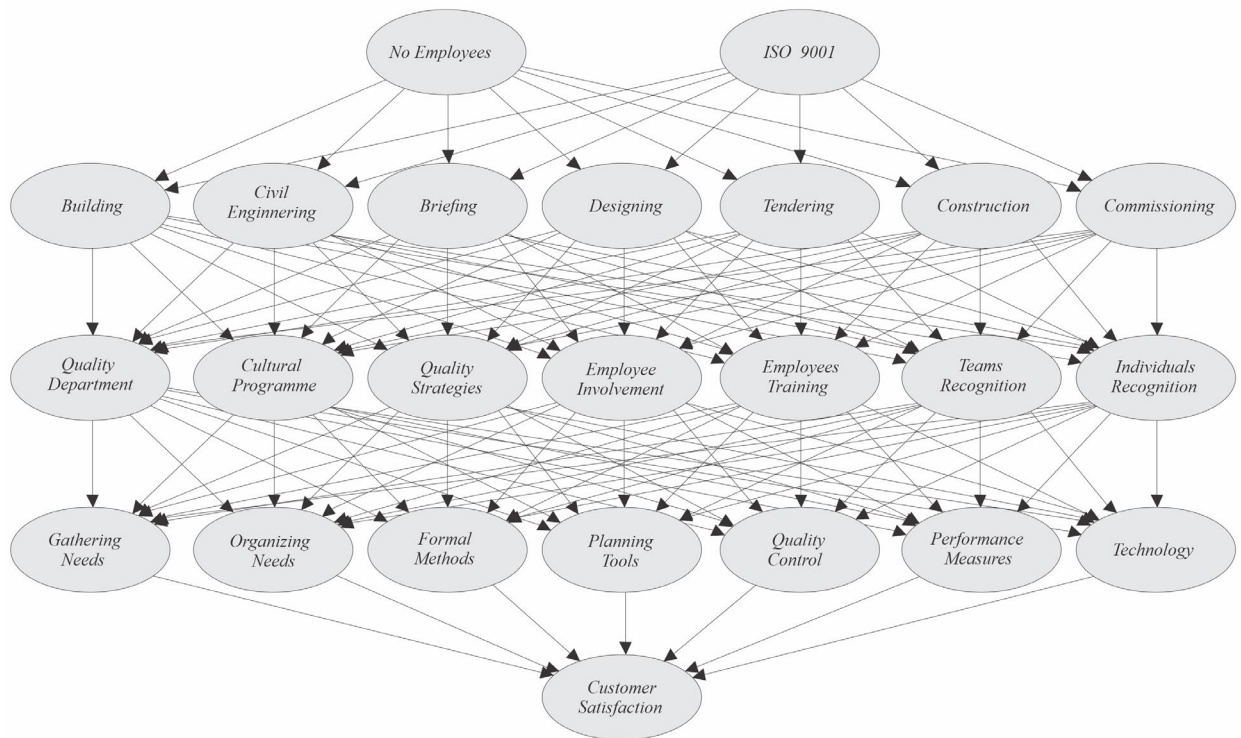


Figure 1. The proposed BN (Adapted from: UNINET®)

Again, every variable can only assume two different states. Note that the node number of employees includes “250 or Less” and “More than 250”, and the node customer satisfaction considers “not satisfied” and “satisfied”. Figure 2 shows them. Consequently, the model is a discrete BN. Note that all variables present the percentage associated with the “true” state. For instance, number of employees shows the value 68.1%, which means that 68.1% of the businesses sampled had more than 250 people working. The node ISO 9001 has the percentage 39.6%, that

signifies that 39.6% of the companies considered had such a certificate. In terms of the customer satisfaction variable, its default value corresponds to 54.0%. This means that, in general, customers of the organizations asked tend to be more satisfied than their unsatisfied counterparts (54.0% vs 46.0% respectively).

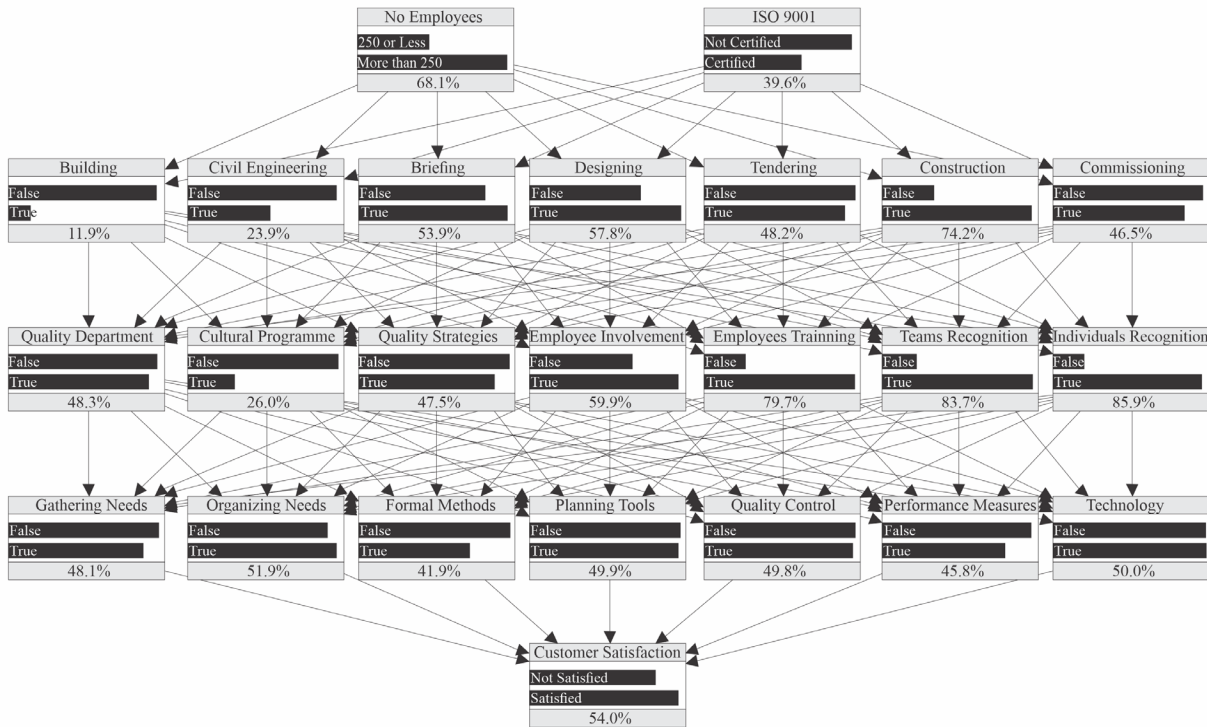


Figure 2. Nodes' states of the proposed BN (Adapted from: UNINET®)

Making use of UNINET®, the network was utilized to carry out different analyses. It should be emphasized that the BN can predict, or diagnose, the performance in any of the Mexican companies included in the original sample (Delgado-Hernández et al., 2017). Now that the mathematical network has been described, its use will be illustrated in the following paragraphs.

### Bayesian Network Results

To determine whether the network has made academic advances, some hypothetical scenarios will firstly be explored. Bear in mind that the default value for the variable customer satisfaction is 54.0%. The analyst wants to know the effect of one particular company profile in such a node.

Then, assume that it is a firm with more than 250 workers, its main activity is related to the designing process, it has a cultural change programme in place, and it makes use of quality control tools. With this evidence, the node customer satisfaction is updated to 57.3%, as shown in Figure 3a. In contrast, now assume that there is a second firm, with less than 250 employees, not directly involved in the designing process, without any cultural change programme in place, and that it neglects the use of quality control tools. This new evidence leads to a value of 51.8% for the customer satisfaction node (see Figure 3b). Consequently, customers of the first hypothetical business would be more satisfied than those of the second case. The difference would be 5.5% (57.3% - 51.8%). This evidence suggests that, as expected, implementing a cultural change programme and utilizing quality control tools have a positive impact on customer satisfaction.

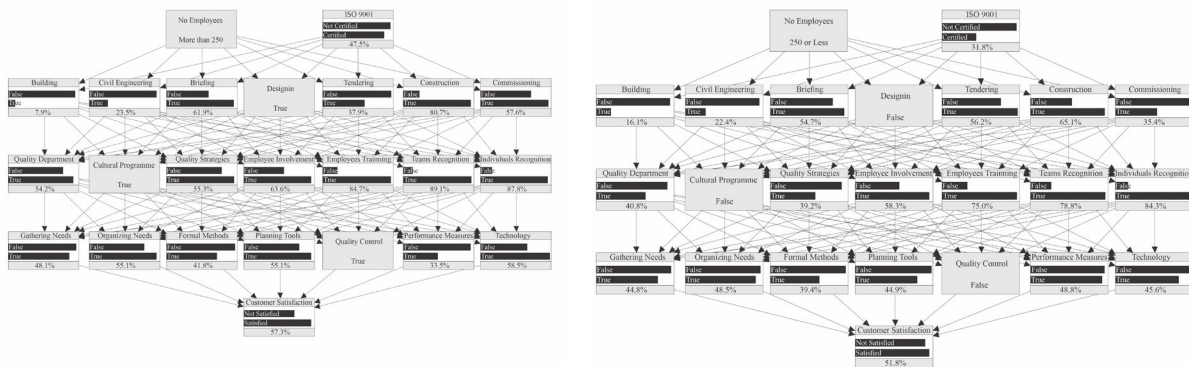


Figure 3. (a) Model with evidence of a company with more than 250 employees (b) Model with evidence of a company with less than 250 employees.

Even more, accept the existence of a company that has been certified to ISO 9001, mainly involved in construction activities, with a quality department in place and that it uses technology on a daily basis. In this case, the customer satisfaction reaches a value of 60.4% (see Figure 4a). In comparison, an organization that has not been certified to ISO 9001, without involvement in construction works, without a quality department and that makes scarce use of technology, would have only 47.5% of customer satisfaction (see Figure 4b). Now the difference is 12.9% (60.4% -

47.5%). This means that having both a quality certificate and a quality department can contribute to increase the client's level of satisfaction. It is no surprise to see technology as an important tool, since this is the age of computers and software.

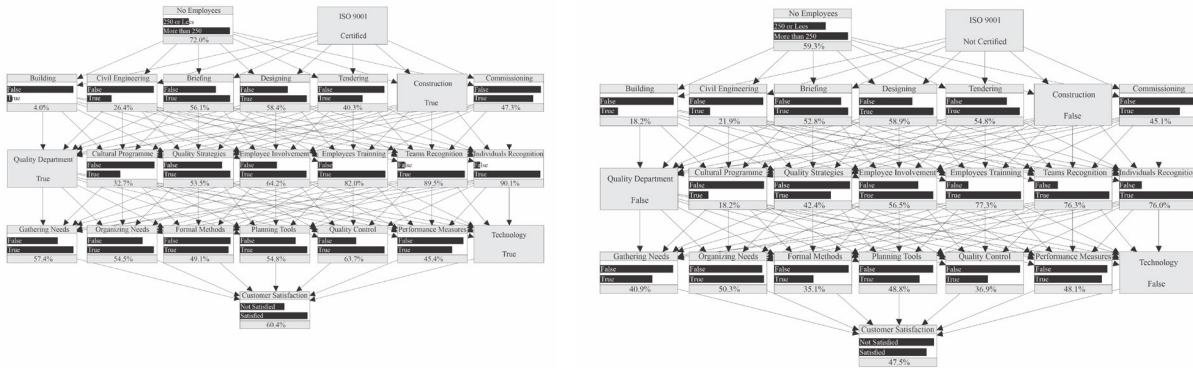


Figure 4. (a) Model with evidence of a company certified to ISO 9001 (b) Model with evidence of a company not certified to ISO 9001.

As already stated, the model allows the analyst to consider multiple scenarios. For instance, in the case of a business with more than 250 employees, with ISO 9001 certification, working in construction sites, with a quality department in place, that makes use not only of technology but also of tools for gathering customer needs, the level of satisfaction increases up to 64.1% (see Figure 5a). Its counterpart would only reach a value of 43.9% (see Figure 5b). Now the difference is 20.2% (64.1% - 43.9%). This result suggest that the more quality initiatives practiced and management tools utilized, the better is the chance to increase customer satisfaction.

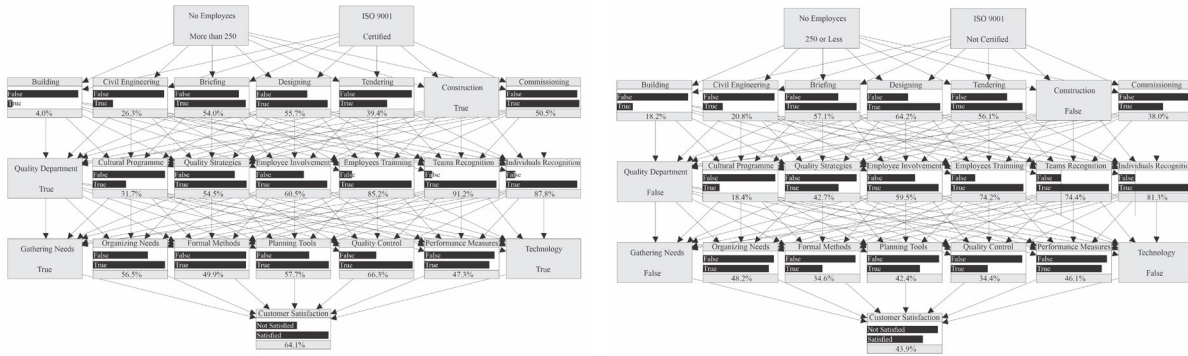


Figure 5. (a) Model of a company with more than 250 employees and certified to ISO 9001 (b) Model of a company with less than 250 employees and not certified to ISO 9001.

Having presented the previous hypothetical examples, now some actual cases of Mexican organizations will be discussed. So, companies of the original database will be analyzed (Delgado-Hernández et al., 2017). To establish whether the implementation of quality initiatives and the use of management tools have been translated into better customer satisfaction in practice, the model has been used. In the exercise, it became clear that the highest value (65.8%) was registered in one firm with less than 250 employees, certified to ISO 9001, involved in five stages of the construction process, with four quality initiatives frequently applied, and two groups of tools commonly utilized. Table 2 shows in detail this company’s profile.

No employees	ISO 9001	Activities	Initiatives	Management tools	Customers Satisfaction
250 or Less	Certified	Briefing	Quality Department	Gathering Needs	65.80%
		Designing	Cultural Programme	Technology	
		Tendering	Employee Involvement		
		Construction	Employees Training		
		Commissioning			

<b>No employees</b>	<b>ISO 9001</b>	<b>Activities</b>	<b>Initiatives</b>	<b>Management tools</b>	<b>Customers Satisfaction</b>
250 or Less	Certified	Briefing	Quality Department	Gathering Needs	64.60%
		Designing	Quality Strategies	Quality Control	
			Employee Involvement	Technology	
			Employees Training		
			Teams Recognition		
			Individuals Recognition		
250 or Less	Certified	Construction	Quality Department	Gathering Needs	62.90%
			Cultural Programme	Quality Control	
			Quality Strategies		
			Employee Involvement		
			Employees Training		
			Teams Recognition		
			Individuals Recognition		
More than 250	Certified	Construction	Quality Department	Organizing Needs	51.60%
			Quality Strategies	Formal methods	
			Employee Involvement	Planning Tools	
			Employees Training	Quality Control	
			Teams Recognition	Performance measures	
More than 250	Not Certified	Building	Cultural Programme	Organizing Needs	47.90%

No employees	ISO 9001	Activities	Initiatives	Management tools	Customers Satisfaction
		Construction	Employee Involvement	Performance measures	
		Commissioning	Employees Training		
More than 250	Certified	Building	Employee Involvement	Organizing Needs	47.90%
		Briefing	Employees Training	Formal methods	
		Designing	Teams Recognition	Performance measures	
		Tendering	Individuals Recognition		
		Construction			
		Commissioning			

Table 2. Mexican construction companies' profiles.

The second highest level of customer satisfaction was 64.6%. It corresponds to one organization with less than 250 employees, certified to ISO 9001, involved in two stages of the construction process, with six quality initiatives frequently applied, and three groups of tools commonly utilized (see Table 2). In the same line of thought, the third place reached a value of 62.9%. In this case, the firm had also less than 250 people employed, was certified to ISO 9001, was working only on construction projects, had implemented seven quality initiatives and made use of two groups of tools. The relatively good performance of these businesses could be the result of the adoption of quality management standard's certification. Even more, the three can be

considered as small businesses in terms of their number of employees. This is an advantage, since they are flexible with simple structures, result oriented, and with versatile employees.

On the other hand, the three lowest levels of customer satisfaction were found in big companies, i.e., those with more than 250 employees. The values were 51.60%, 47.90% and, again, 47.90%. Surprisingly, only one had not been certified to ISO 9001. Another common factor was their involvement in construction activities (see Table 2). In terms of the initiatives, they had implemented between three and five, ranging from quality strategies through to all types of recognition. Regarding the use of the management tools of interest, none of the businesses reported the utilization of technology, although they made intensive use of performance measures. Under these circumstances, in the following section some practical implications will be put forward and the limitations of the study will be pointed out.

### **Practical Implications and Discussion**

The cases presented are enough to identify concurrent and divergent issues. All the companies shown in Table 2 have implemented at least two out of the seven quality initiatives considered. However, their levels of customer satisfaction vary on the basis of number of employees, quality certifications and management tools. Small and Medium Enterprises (SME's) perform better than their large counterparts. The flexibility of SME's is far greater than that of large companies. Maybe this allows them to focus better on their customer needs, and to spend more time satisfying them. With reference to the ISO 9001 certification, authors such as Hadidi, Assaf, Aluwfi, and Akrawi (2017), Niranjana and Nisha (2018), and Tomic and Brkic (2019) have reported a correlation between its application and customer satisfaction. Here, the focus should be on quality management rather than on quality control.

Regarding the existence of a quality department, in general, the firms that have adopted such initiative tend to have better levels of customer satisfaction than those that neglect it. This result

is in line with the findings recently reported, in the Mexican context, by García-Alcaraz et al. (2021). They argued that the role of a quality department is crucial to deploying quality policies and reaching customer satisfaction and, in the end, loyalty. In addition, they emphasized that attention needs to be paid to the managerial commitment to implement quality strategies.

With regard to the employees' training, either the best or the worst performers in terms of customer satisfaction apply it on regular basis. This finding reveals that construction businesses are aware of the role that training plays in the management of quality. Moreover, this result is in accordance with that reported by Sweis et al. (2019), who claimed that there is a positive and strong correlation between employees' training and the performance of construction organizations.

In terms of the management tools, the best companies made use of both the gathering customer needs and the technology groups. As can be seen in Table 1, previously presented, the first group includes: customer surveys, customer one-to-one interviews, customer telephone interviews, brainstorming and focus groups. In the construction sector, the idea to gather the client's requirements has been put forward for a while now. Delgado-Hernandez and Aspinwall (2007) reported the use of questionnaires and focus groups to improve customer satisfaction in the design and construction phases of different nurseries in the UK. More recently, Juan, Hsing, and Hsu (2019) revealed that future public housing projects should take into account multi-generational living arrangements, energy-efficient and barrier-free designs, flexible spaces, crime prevention and self-sufficient farming. These aspects were discovered by means of customer surveys and interviews. As a result of their inclusion in the buildings, customer satisfaction may be increased. The second group of tools includes: planning software, design software, finite element analysis software and computer networks. Undoubtedly, as Vasista and Abone (2018) sustained, the

computer programs and networks can help to improve customer satisfaction by diminishing coordination errors, and enhancing participants' understanding for better handling issues and requirements. These results may be integrated in current methodologies for selecting management tools. For instance, in the one proposed by Rocha-Lona et al. (2013) and presented earlier. Basically, in their second stage i.e., models, methods, and tools screening for suitability, construction managers should analyze the groups associated with gathering customer needs and technology. In parallel, the associated implementation costs and required resources to put them into practice should be examined. As a result, the best candidate tools should be chosen for increasing customer satisfaction, based on the model's predictions.

Admittedly, the number of variables included in the model, the size of the companies' sample in which its construction was based, and the two states per variable are not exhaustive. They may be used as a starting point to develop a more comprehensive BN. However, the hypothetical cases analyzed, the actual Mexican construction companies studied and the implications summarized, have helped to show that the model is both practical and applicable. From a professional standpoint, the findings of this investigation will help companies in the sector to choose a variety of management tools useful to enhance customer satisfaction. Essentially, the two groups gathering customer needs and technology should be adopted in first place, prior to implementing more complex groups such as formal methods. Moreover, the establishment of a quality department is highly recommended.

As can be seen, the results presented here provide evidence that these groups of tools have worldwide implications in the industry. Consequently, the main contribution of the Mexican case is the opportunity to help businesses in the global sector to better select the categories evaluated. This in turn is useful to increase customer satisfaction to further expand the competitiveness of

the construction community. Having clarified this, the last section of the paper will present the main conclusions of the research.

## **Conclusions**

This paper has dealt with the selection of management tools for improvement in the construction industry. A previous study (Delgado-Hernández et al., 2017) constituted the foundation to propose a quantitative model for identifying those that can have a positive impact on customer satisfaction. It is a BN with twenty-four nodes that has been proved both theoretically and practically in a Mexican sample. The first observation is that regardless of their activity in the construction process (i.e., briefing, designing, tendering, construction and commissioning), firms have room for improving user approval. The levels of satisfaction in the sample ranked from 47.90% to 65.80%.

The results also showed that not only the tools designed to gather customer needs were relevant, but also the adoption of technology. While the first outcome was expected, the second might be due to its advantages in standardizing information, transferring data between project members, and establishing a common language among them. This is in line with previous studies such as those of Vasista and Abone (2018), Tomic and Brkic (2019) and García-Alcaraz et al. (2021).

In terms of size, companies with less than 250 employees reached higher levels of customer satisfaction than their large counterparts. The flexibility of SME's was an advantage for the implementation of quality initiatives and strategies aimed at satisfying customer needs. Regarding the certification to ISO 9001, the firms that had adopted the standard performed better than those without it. This reflects better internal management, efficiency and, eventually, customer satisfaction. Concerning the use of initiatives, quality department, quality strategies and employees training were the three most relevant for the construction context. Their combined use

is expected to improve the client experience. Generally speaking, the findings are consistent with previous investigations carried out in various countries.

While the objectives of the research have been achieved, there are still some limitations related to the work. The number of companies reported in the previous study (Delgado-Hernández et al., 2017) should be further expanded. Note, however, that the resultant BN has been successfully used in a Mexican sample. With reference to the number of variables and states, new nodes could certainly be incorporated in the future. This point was not considered from the outset, because it was founded on a previous study (Delgado-Hernández et al., 2017).

Therefore, the originality of the paper lies on that it proposes a BN for selecting improvement management tools to increase customer satisfaction in the construction sector, based on empirical evidence. It is believed that this research will be valuable to many companies not only in Mexico but also in other countries, and will encourage future investigations in the construction industry.

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## **Conclusiones finales**

Los resultados aquí presentados proporcionan evidencia de que estos grupos de herramientas tienen implicaciones en la industria.

Uno de los aportes de esta investigación es la oportunidad de ayudar a las empresas del sector a seleccionar mejor las herramientas e iniciativas, esto a su vez, es útil para aumentar la satisfacción del cliente y ampliar aún más la competitividad de la comunidad de la construcción.

Se observa que los valores de satisfacción del cliente no llegaron más allá del 70% en la industria de la construcción, en contraste se cree que en la industria manufacturera pueda llegar a alcanzar niveles por encima, debido a los diferentes estándares de calidad que se manejan dentro de la industria manufacturera.

Las principales barreras para obtener valores de satisfacción del cliente mayores a los obtenidos se cree que tienen que ver con características de naturaleza de los proyectos: los proyectos a menudo son muy grandes, requieren mucha mano de obra y rara vez se encuentran en el mismo lugar y la fuerza laboral tiende a ser transitoria.

Un plan de proyecto, puede cambiar varias veces durante la construcción, esto genera retrasos en los programas de construcción, cronogramas, tiempos de ejecución, tiempos de entrega y defectos de construcción.

La muestra utilizada para el modelo se realizó con empresas mexicanas que radican en el centro del país, futuras investigaciones podrían desarrollarse con una muestra de empresas extranjeras y comparar los resultados con el uso del modelo en empresas nacionales en comparación con empresas transnacionales.

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# Anexo A Cuestionario para la Investigación sobre Herramientas de Calidad en la Industria de la Construcción Mexicana

## CUESTIONARIO PARA LA INVESTIGACIÓN SOBRE HERRAMIENTAS DE CALIDAD EN LA INDUSTRIA DE LA CONSTRUCCIÓN MEXICANA

### Introducción

Este cuestionario es parte de un estudio que pretende determinar la amplitud de uso de las diferentes herramientas de calidad, en la industria de la construcción Mexicana. Los resultados se usaran con fines de investigación y servirán de base para el desarrollo de un modelo capaz de indicar las técnicas mas adecuadas para aumentar la calidad en los proyectos de construcción, en función del tipo de proyecto. De ninguna forma se intentara identificar a las empresas o a los individuos que tomen parte en el estudio.

### Instrucciones

El cuestionario consta de cuatro secciones. Por favor indique por medio de una cruz (X) las opciones mas apropiadas o complete las preguntas en los espacios dados.

### Sección I – Información General

En esta sección se solicita información general de la empresa.

1 – ¿Cuál es el número aproximado de empleados en la compañía?

250 o menos                       Más de 250

2 – ¿Qué tipo de proyectos se llevan a cabo? (Por favor indique tantas opciones como sea necesario)

Edificación                       Obra civil       Otro (Por favor especificar):

3 – ¿En que etapa(s) del proceso de construcción participa la compañía?

Anteproyecto                       Diseño                       Concurso                       Construcción  
 Entrega de obra                       Otro (Por favor especificar): \_\_\_\_\_

### Sección II – Iniciativas de Calidad

Esta sección indaga las iniciativas, que para mejorar la calidad, la compañía ha implementado. Si la empresa no cuenta con sistema de calidad alguno, entonces diríjase a la sección III.

4 – ¿Está la compañía certificada con la norma ISO-9001?                       Si                       No

5 – Si es así, ¿en qué año obtuvo el certificado?                      Año \_\_\_\_\_

6 – ¿Está la compañía certificada con la norma ISO-14001?                       Si                       No

7 – Si es así, ¿en qué año obtuvo el certificado?                      Año \_\_\_\_\_

8 – ¿Está la compañía certificada con alguna otra norma o sistema?                       Si                       No

9 – Si es así, ¿con cuál? y ¿en qué año obtuvo el certificado?

Número \_\_\_\_\_                      Año \_\_\_\_\_

10 – ¿Cuál(es) de las siguientes iniciativas se han implementado en la empresa?

Creación de un departamento de calidad                       Participación de los empleados para mejorar la calidad  
 Programas de cambio de cultura                       Iniciativas para satisfacer a los clientes  
 Desarrollo de estrategias de calidad total                       Otra (Por favor especificar):

11 – Aproximadamente, ¿cuándo se comenzaron a implementar estas iniciativas?                      Año \_\_\_\_\_

### Sección III – Herramientas de Calidad

Esta sección considera el uso que la empresa hace de una variedad de herramientas, disponibles para mejorar la calidad de sus productos/servicios. Por favor indique el **nivel de uso** y la **importancia** que usted percibe de cada una de las herramientas listadas, dentro de su empresa.

**(1) Muy bajo    (2) Bajo    (3) Moderado    (4) Alto    (5) Muy alto**

Si la herramienta no le es familiar, no aplica al tipo de actividad de la empresa o no esta seguro de cómo contestar, por favor marque el **(0)**. (Nota: entre paréntesis encontrará algunas siglas en inglés, que indican el nombre de la técnica en dicho idioma).

0	Uso					Herramienta, técnica o método de calidad	0	Importancia percibida						
	1	2	3	4	5			1	2	3	4	5		
						<b>Necesidades del cliente</b>								
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Encuestas a los clientes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Entrevistas personales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Entrevistas telefónicas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lluvia de ideas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Grupos de enfoque	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<b>Organización de las necesidades del cliente</b>								
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Diagramas de afinidad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Diagramas de árbol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Diagramas de matrices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<b>Métodos formales</b>								
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Función del despliegue de calidad (QFD)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Teoría para resolver problemas inventivos (TRIZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ingeniería concurrente (CE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<b>Planeación</b>								
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Enunciar la misión del proyecto o empresa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Diagrama de barras de Gantt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Método de la Ruta Crítica (CPM)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Redes (PERT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Trabajo en equipo	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Análisis del objetivo de cada departamento	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<b>Control de calidad</b>								
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Leyes y reglamentos	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Listas de verificación	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5Ss (Housekeeping)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Inspección	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Muestreo	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Auditorías de calidad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Relación con contratistas y/o proveedores	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

0	Uso					Herramienta, técnica o método de calidad	0	Importancia percibida					
	1	2	3	4	5			1	2	3	4	5	
						<b>Medidas para evaluar las iniciativas de calidad</b>							
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Encuestas de satisfacción del cliente	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Quejas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Litigios	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<b>Tecnología</b>							
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software de planeación (ej: primavera, ms project)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software de diseño (ej: autoCAD)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software de cálculo (ej: SAP 2000)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Red de computadoras (ej: e-mail)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Otro (Por favor especificar):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

#### Sección IV – Asuntos Relacionados con la Calidad

En esta última sección se presentan algunos asuntos generales relacionados con la calidad.

- 12 – ¿Cree que la calidad de los productos/servicios de su empresa podría ser mejorada?     Si     No
- 13 – ¿Los gerentes de su empresa están comprometidos con la calidad?     Si     No
- 14 – ¿Los empleados de su empresa reciben entrenamiento en alguna de las herramientas listadas en la sección III?     Si     No
- 15 – ¿En su compañía se reconocen los esfuerzos de los equipos?     Si     No
- 16 – ¿En su compañía se reconoce el esfuerzo de los individuos?     Si     No
- 17 – ¿Le gustaría recibir los resultados de este estudio?     Si     No
- (Si es así, anexe una tarjeta personal o de la empresa)**

Comentarios adicionales (opcional): Gracias por la iniciativa, por favor manténgame enterado de sus avances, resultados y propuestas. \_\_\_\_\_

**GRACIAS POR COMPLETAR EL CUESTIONARIO  
TODAS LAS RESPUESTAS SERAN TRATADAS ANONIMAMENTE.**

## Anexo B Perfiles de Empresas Constructoras Mexicanas

No Empleados	ISO 9001	Actividades	Iniciativas	Herramientas de Gestión	Satisfacción Cliente
Menos de 250	Certificado	5	4	2	65.8%
Menos de 250	Certificado	2	6	3	64.6%
Menos de 250	Certificado	1	7	2	62.9%
Menos de 250	No certificado	5	4	5	62.8%
Mas de 250	Certificado	1	7	5	62.1%
Mas de 250	No certificado	2	7	4	61.8%
Mas de 250	Certificado	5	5	2	61.1%
Menos de 250	Certificado	2	5	5	61.1%
Menos de 250	Certificado	3	6	6	60.9%
Mas de 250	Certificado	4	7	5	60.6%
Mas de 250	Certificado	1	4	3	60.3%
Mas de 250	No certificado	5	7	3	60.2%
Mas de 250	No certificado	4	3	5	59.9%
Menos de 250	Certificado	5	4	7	59.6%
Menos de 250	Certificado	5	6	7	59.6%
Mas de 250	No certificado	5	3	7	59.5%
Mas de 250	No certificado	6	3	7	59.4%
Mas de 250	No certificado	5	4	5	59.1%
Menos de 250	Certificado	2	7	4	59.0%
Mas de 250	No certificado	2	5	4	58.7%
Mas de 250	No certificado	3	2	5	58.6%
Mas de 250	No certificado	2	3	4	58.3%
Menos de 250	Certificado	2	6	6	58.1%
Mas de 250	No certificado	1	3	6	57.9%
Mas de 250	Certificado	4	6	3	57.5%
Menos de 250	Certificado	0	6	3	57.4%
Mas de 250	No certificado	1	2	3	57.1%
Mas de 250	No certificado	6	3	1	57.1%
Menos de 250	No certificado	3	3	2	56.2%
Mas de 250	No certificado	1	6	0	56.1%
Mas de 250	No certificado	1	3	4	56.0%
Mas de 250	No certificado	2	2	0	55.9%
Mas de 250	No certificado	2	4	0	55.4%
Mas de 250	No certificado	3	4	0	55.1%
Mas de 250	No certificado	6	5	2	54.9%
Menos de 250	No certificado	2	3	2	54.9%
Menos de 250	Certificado	5	3	2	54.7%
Mas de 250	Certificado	5	6	5	54.6%

<b>No Empleados</b>	<b>ISO 9001</b>	<b>Actividades</b>	<b>Iniciativas</b>	<b>Herramientas de Gestión</b>	<b>Satisfacción Cliente</b>
Mas de 250	No certificado	2	3	0	54.6%
Mas de 250	No certificado	3	5	6	54.4%
Mas de 250	No certificado	3	4	3	54.1%
Mas de 250	No certificado	2	6	3	53.9%
Menos de 250	No certificado	1	0	0	53.5%
Mas de 250	No certificado	5	1	0	53.3%
Mas de 250	No certificado	4	3	3	53.3%
Mas de 250	No certificado	4	4	0	53.1%
Menos de 250	Certificado	6	4	5	52.7%
Mas de 250	Certificado	1	5	5	51.6%
Mas de 250	No certificado	3	3	2	47.9%
Mas de 250	Certificado	6	4	3	47.9%

Tabla 3. Perfiles de Empresas Mexicanas.