



Research paper

A method for estimating the influence of advanced manufacturing tools on the manufacturing competitiveness of *Maquiladoras* in the apparel industry in Central America



Jared R. Ocampo^{a,*}, Juan Carlos Hernández-Matías^b, Antonio Vizán^b

^a School of Engineering and Architecture, Universidad Tecnológica Centroamericana (UNITEC), Carretera a Armenta contiguo a Altia Business Park, San Pedro Sula, Honduras

^b Department of Mechanical and Manufacturing Engineering, E.T.S. Ingenieros Industriales, Polytechnical University of Madrid (UPM), José Gutiérrez Abascal 2, 28006 Madrid, Spain

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ABSTRACT

Globalization has fostered the development of a laborintensive, export-oriented assembly industry known in Latin America as *Maquiladora* Industry, which is one of the most important industrial sectors in Central America and the Caribbean. The use of advanced manufacturing tools (AMTs) in their manufacturing operations can help to improve their performance and competitiveness. This paper proposes a method that uses correlation analysis and structural equation modelling for identifying the influence that AMTs have on the manufacturing competitiveness of *Maquiladoras* in Central America. An empirical test using this method in *Maquiladoras* in the apparel industry in Honduras shows a positive effect between AMTs use and manufacturing competitiveness, especially in the delivery time and environmental protection factors.

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1. Introduction

The competition posed to companies by globalization has forced them to seek ways to reduce costs, improve product quality, enlarge product assortment and provide reliable deliveries to become more competitive [1]. One way to increase their competitiveness is to establish multinational enterprises, in order to obtain supplies from places in the world that offer the best possible mix of value and cost. That may translate to companies manufacturing their products in countries with cheap labor, and then selling them in markets where a higher selling price is possible [2,3]. This practice has led to the establishment of an export-oriented, labor-intensive, assembly industry in countries with a less developed industrial base and a low human development index, but with a strong emphasis on textiles and electronics manufacturing [4,5]. The later allows these companies to manufacture products and offer services at affordable prices, with the required quality and in the established time frame of its multinational corporation stakeholders, which, in turn, are then commercialized in developed nations.

The arrival of this export-oriented assembly industry, known in Latin America as “*Maquiladora Industry*”, has significantly boosted the manufacturing activity of Mexico, Central America and the Caribbean [6]. In the same way that the North American Free Trade Agreement (NAFTA) greatly benefited Mexico with the *maquila's* regime, the Dominican Republic–Central America–United States Free Trade Agreement (DR-CAFTA) and the integration of the Central American Common Market Place (CACM) have enhanced Central American exports. In fact, according to Vargas–Hernández and Núñez–López [7] over half of exports in the Central America region come from this industry, with over 90% of its sales made to the United States. Particularly, the *maquila* industry dedicated to apparel production (which accounts for 90% of the total *maquila* exports) generates direct employment and income to entire communities where the livelihood of thousands of people depends on its success [8,7].

However, the pressure that is actually being faced by businesses due to globalization, especially with the entry of Asia and particularly of China to the assembly production offering market, is also applicable to this industry. That, along with the slowdown in

* Corresponding author.

E-mail addresses: jared.ocampo@unitec.edu (J.R. Ocampo), jc.hernandez@upm.es (J.C. Hernández-Matías), antonio.vizan@upm.es (A. Vizán).

the world economy, has presented serious problems for the Latin-American *maquila* industry [9,87], making it necessary for it to rethink its strategies, processes and procedures, trying to make them more efficient and competitive, in order for them to stay in business.

In recent years, the use of Advanced Manufacturing Technologies (AMT) has been known to effectively reduce cost, improve performance and produce a sustainable competitive advantage in business Koc and Bozdog [47], therefore increasing competitiveness. The classic definition of AMT is usually related to technologies that apply mechanical, electrical or electronical systems controlled by computers for product design, production programming, control and execution [10]. However, some authors have also included as part of the AMT some methodologies such as TQM (Total Quality Management), JIT (Just In Time) and Lean Manufacturing [11,12], all of which are often used to increase the effectiveness and performance of companies. Then, questions that apparel industry managers may be asking themselves are: Can the use of advanced manufacturing technologies and methodologies in the operating processes and manufacturing strategy of *maquiladoras* increase their competitiveness? Will the use of these tools increase the performance of their manufacturing plants such as the ability to respond faster to customer needs or to manufacture products of higher quality and reliability at lower prices?

Although there are a few studies that test the effects of both: manufacturing technologies and management methodologies on manufacturing competitiveness [13,12,14], these were done with a reduced scope of tools. Additionally, while there are studies that have reviewed the use of AMT in developed countries and large industries [15,16], there is a lack of empirical studies about these relationships in multinational companies (*maquiladoras*) located in developing countries that can offer external validation to the findings obtained in highly industrialized nations and other types of industries. Our study builds on this previous knowledge by testing the effects of both technologies and methodologies (known henceforth as Advanced Manufacturing Tools), using a new tool taxonomy that expands the scope of the tools tested before. Therefore, the main purpose of this paper is to propose a method to identify the influence that the use of Advanced Manufacturing Tools (AMTs) has on the manufacturing competitiveness of *maquiladoras*. This method is afterwards used in a specific case study in *maquiladoras* dedicated to the apparel industry, located in Honduras, which is a developing country located in Central America. The purpose of the case study is showing the application of the proposed method step-by-step so the reader can understand it better and replicate it if required. The acquired knowledge of these relationships and effects will provide important information for *maquiladoras* seeking to improve their performance in specific manufacturing objectives or considering investing in certain AMTs.

Since the literature shows that competitive priority emphasis and AMT usage level change over time and vary in importance, depending on the region and the industry in which they are studied [17–19], AMT usage and its influence in manufacturing competitiveness needs to be studied in specific regions and industries. Hence, this study has chosen to study the influence that the use of AMTs has on the manufacturing competitiveness in the *maquiladora* industry in Central America. Additionally, there is a probability that the manufacturing competitive factors in companies located in developing countries and the impact of AMTs in those factors vary from those in developed nations. This is because innovation processes in developing countries are incremental and based on absorption, and not in the radical changes observed in non-developing nations [20]. Also, in these countries, the knowledge and technology transfer is generally based in spillovers and imitation, than in the focus on R&D activities from universities

and research institutes in developed nations [21,22]. Furthermore, it is logical to think that the use of improvement methodologies and automation technologies can have a higher impact in the competitiveness of companies dedicated to labor-intensive processes due to improvements in efficiency, than in other types of industries. Finally, these types of industry-specific studies help to avoid the problems of high level abstraction and generalization across industries and countries that deters managers from considering the results applicable and relevant for their industry [23,24].

2. Theoretical background

2.1. Estimating manufacturing competitiveness

There is not a universally accepted definition of competitiveness; however, there is a common agreement that a country or a company is more competitive if it has better performance than their counterparts in specific areas of interest. Competitiveness can be measured at the national, regional and industry level (macroeconomic level), as well as at the company and product level (microeconomic level). Despite the strong correlation existing between country competitiveness and the competitiveness of individual companies, there are differences in the way both are measured [25]. For instance, to measure national competitiveness, hundreds of objective and subjective indicators have been used by international organizations such as the World Economic Forum (WEF) and the Institute of Management Development (IMD). However, to measure company competitiveness most authors use almost exclusively financial indicators [26] which is not always an accurate representation of the real competitiveness of a company. Therefore there is need to consider other type of indicators to measure the manufacturing competitiveness of factories.

Although it is easier to compare companies' performances using financial metrics, it is good to remember that the factors that lead to being competitive are usually non-financial. For instance, authors such as [27–29], explain that competitive advantage can be acquired by possessing resources, capabilities or organizational routines that differentiate them from others. For Carpinetti et al. [30], a company's manufacturing competitiveness is mostly dependent upon how well it performs in dimensions such as quality, cost, delivery time, flexibility to change, innovation, and customer service. It makes sense to think that the use of these dimensions, known in the strategic management literature as competitive priorities [17,18], can be a good way to measure manufacturing competitiveness. Different authors agree that four competitive priorities are fundamental: cost or efficiency, flexibility, quality and delivery time [18,31]. However, other authors have added to these priorities: innovation [32,33], customer service [34,35], and environmental protection [36,37].

The competitive priorities are multidimensional by nature, meaning there is a group of components or dimensions that explain each priority or help to measure them. According to the literature review, these components vary depending on the industry or market under study [38,37,39]. Fine and Hax [40] state that it is impossible to excel in all of these priorities simultaneously, however it is possible to emphasize in a group of them which are of greater importance for a company making it necessary to establish a balance or trade-off between them. Several studies have tried to find these priorities and order them according to their importance to an industry or market using empirical analysis of the perception of company directors, vice presidents or managers [41,42], or expert opinion [3]. In either case, the responses are weighted using different equations or algorithms

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