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ORIGINAL ARTICLE

Main benefits obtained from a successful JIT implementation

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Abstract Literature has reported 31 benefits obtained by companies after a successful JIT implementation. However, this research reduces the list by means of a data reduction technique to identify those essential benefits that must be pursued. The 31 benefits are integrated in a questionnaire that is administered to 144 production managers in maquiladoras in Mexico to measure the extent to which they are obtained according to respondents. One the one hand, a validation process and descriptive analysis are carried out for every benefit by considering their median values as a measure of central tendency and interquartile range values as a measure of dispersion. On the other hand, data reduction was achieved by means of a factor analysis based on principal components and varimax rotation. Four main factors related to JIT benefits are identified after the factor analysis, which explain 67.27 % of total variance of data. Identified factors concern inventory management, production process, human resources, and economic benefits.

Keywords JIT benefits · Factor analysis · Data reduction · JIT implementation · Maquiladora

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1 Introduction

Global competition nowadays forces manufacturing companies to improve customer satisfaction. Moreover, due to this globalization phenomenon, companies have focused on reducing costs, improve quality, and diversify products and services [1–3]. However, they usually face fluctuations in demand that require rapid adjustment of manufacturers to fulfill requirements of costumers [4–6]. As a result, such manufacturing organizations must adapt, readapt, and redesign their production processes. Therefore, it can be stated that the stability and survival of manufacturing companies in an increasingly competitive world depend on the ability of these firms to produce higher-quality products at a lower cost and in allowable delivery times [2].

Research has focused on the identification of strategies that could allow manufacturing companies to survive in the current state of market and preserve the preferences of their clients [1, 7]. One of the most successful strategies to reach these objectives is to provide high-quality products at reliable and reduced delivery times in the supply chain within globalized production systems. In fact, it is very common that components or parts of a product are manufactured in one country, while the final assembly is executed in another country or region. To achieve these goals, companies have drawn upon several techniques, methods, and strategies among which just-in-time (JIT) has shown salient presence.

JIT makes it possible for companies to obtain the competitive advantage required. Its elements are effective to respond to current changes, speed, and efficiency demanded in the market [8]. Furthermore, recent research indicates that JIT

today has become more important than in previous years due to the impact of globalization in production processes [9]. For instance, a great amount of foreign companies establish on the Mexican borderland with USA for the final assembly of products. However, the components of such products originate from other countries. As a result, raw material import and final product export require a JIT process.

1.1 JIT concept

JIT is not a novel concept, although its definition has evolved from the strict sense of production system to reach the notion of a general management philosophy to satisfy customers and gain a competitive advantage in the market. Moreover, JIT is currently considered as a soft advanced manufacturing technology [10], but it is also commonly used in the service sector. A first approach of JIT describes it as the ability to have the correct part at the appropriate time and amount [11, 12]. However, a JIT manufacturing system has recently based on a philosophy of waste elimination [1, 13], using the total capacity of every worker to obtain the maximum benefits [1] and minimizing raw material movements, low work in process, and low inventory of finished products, which usually help detect other serious deficiencies along the production process [14].

Historically, JIT is a manufacturing philosophy developed in Japan, which emphasizes on excellence in all phases of the production cycle [15]. Thus, it covers all aspects of the production process, including organizational management, planning, flexible work in production lines, inventory management, raw material transport, and high-quality relationship with suppliers, to mention but a few. Similarly, JIT covers every stage of the production process, which includes product design, physical distribution, production, processing, and final sales, among others. That is, JIT is a process comprising from product design to final sale [16].

Concepts of JIT vary widely, and confusions may rise regarding what exactly constitutes a manufacturing JIT-based system [17]. For practical purposes, [18] defines JIT as a set of practices implemented in an industrial organization that can be focused on eliminating waste in the production process. Also, authors underline that JIT must be supported for effective practices such as activities and mechanisms that provide JIT support. As a conclusion, JIT manufacturing system can be referred as to a set of JIT practices in production systems and infrastructure practices for a better JIT support.

1.2 Origins and evolution of JIT

JIT philosophy dates back to the decade of 1930 in Japan with the supply systems of shipyards [19], where the excessive number of steelmakers allowed for a remarkably rapid delivery of raw material to boat builders who, in turn, asked suppliers to deliver materials in small quantities and more frequently as a means to reduce inventories of raw materials and minimize costs. This delivery practice was rapidly adopted by other companies and was named just-in-time. Afterward, the practice was also applied in internal processes of companies. Benefits reflected on a reduction of costs and satisfied customers.

This new idea for low and frequent deliveries was later adopted by Toyota Company, also in Japan. The company remarkably improved and sophisticated the approach and, in fact, people tend to associate JIT with the Toyota Production System (TPS), even though other Japanese firms have adopted and continue using such JIT techniques [4, 20].

The Toyota Production System as a philosophy is usually imputed to Taiichi Ohno, vice president of the company who emphasized that all unnecessary functions had to be removed from the production processes [21]. However, JIT was applied to administrative process, too. Also, TPS became known in America in the decade of 1980 when leaders of companies in the USA began analyzing the success of Japanese companies and their production practices. As a result, Wayne Fortun became the pioneer that imported the production philosophy [22].

As previously stated, the concept of JIT has largely evolved and relevant definitions can be found in [23] and [24]. However, it is now being viewed as a methodology [25], a concept [19, 26], a goal [27], a creed [28], a work philosophy [29, 30], a production strategy [31], a program [32], a process [33], a way of thinking [34], a production technique [35], and, finally, a production system [36, 37]. Nevertheless, JIT in production processes is not alone; it is usually combined with another technique, such as simulation [38–40], dynamic programming [41], analysis of variance [40], MRP [42], Kanban [43, 44], or optimal batch size [45, 46]. Therefore, since JIT benefits are usually those pursued by companies, the philosophy is being increasingly adopted.

1.3 JIT benefits

Several authors have addressed the various kinds of advantages that companies in different sectors can obtain from a successful JIT implementation. However, literature of this research highlighted 31 benefits, which were identified from [2] from different papers and industrial contexts. Such benefits are depicted in Table 1 and listed hierarchically according to their number of quotations in several works addressing JIT benefits. Four benefits were cited by more than ten authors.

Increased productivity is ranked in first place with 19 quotations, while *Increased product quality* holds the second position, since it was addressed by 17 works. Similarly, benefits *Improved worker motivation* and *Reduction of waste and rework* hold the third place, since they both reported 11 quotations. Similarly, from a general perspective, one can observe that most elements reporting more than seven quotations are

Table 1 Main benefits obtained from JIT implementation

JIT benefit	References	Quotation
1.Increased productivity	[27, 84–101]	19
2.Increased product quality	[27, 84–90, 92, 96, 98, 101–106]	17
3.Improved worker motivation	[27, 86, 87, 90, 99, 102, 103, 105, 107–109]	11
4.Reduction of waste and rework	[27, 86–89, 91, 94, 96, 101, 107, 110]	11
5.Increased process efficiency	[27, 86–88, 94, 101, 105, 107, 108]	9
6.Increased teamwork	[27, 86, 87, 97, 99, 107, 110, 111]	8
7.Increased process flexibility	[27, 84, 91, 92, 103, 104, 107, 112]	8
8.Established cost reduction	[88, 91, 98, 103, 107, 112–114]	8
9.Manpower cost reduction	[85, 91, 94, 95, 100, 105, 107, 115]	8
10.Reduced space requirements	[84, 86, 87, 92, 100, 101, 105]	7
11.Reduction in part numbers	[84, 86–88, 92, 102, 113]	7
12.Reduced inventory	[86, 87, 100, 101, 105, 116, 117]	7
13.Less overhead	[27, 84, 88, 92, 98, 107]	6
14.Reduced movement distances	[91, 94, 98, 102, 111]	5
15.Reduced classification of positions	[94, 104, 111, 112]	4
16.Increased use of resources	[88, 96, 107, 113]	4
17.Paperwork reduction	[88, 91, 94, 105]	4
18.Reduction in materials handling	[89, 94, 98, 103]	4
19.Better supplier-customer relationships	[106, 116, 118, 119]	4
20.Reduced lead time production	[93, 105, 120]	3
21.Reduction of work in process (WIP)	[86, 87, 92]	3
22.Rapid responses to changes in engineering	[27, 101, 106]	3
23.Increased process quality	[89, 90, 98]	3
24.Increased communication	[102, 107]	2
25.Integration of different activities in manufacturing	[113, 121]	2
26.Increased innovation	[27, 104]	2
27.Purchase of reduced lot sizes	[93, 116]	2
28.Product cost reduction	[27, 105]	2
29.Increased inventory turnover	[100]	1
30.Improved competitiveness	[105]	1
31.Increased financial profit	[105]	1

related to technical and operative benefits. That is, benefits obtained from a successful JIT implementation are mostly related to production processes.

On the other hand, benefits *Increased inventory turnover*, *Improved competitiveness*, and *Increased financial profit* were quoted merely once. However, such low quotation does not indicate their less importance or impact. It may be more suitable to consider that these benefits are rather consequences of others. For instance, since inventory turnover is a goal in JIT, companies consequently obtain financial benefits.

Finally, middle places in Table 1 are occupied by other kinds of benefits associated with communication within the company and suppliers, integration for the production process, and human resources, although worker motivation exceptionally occupies a third place in the list.

1.4 Research problem and objective

Several companies respond to the globalization process by establishing subsidiaries in other countries, which allows them to reach greater proximity to markets. Mexico as a facilitator country enables such subsidiaries—also known as maquiladoras—to gain competitiveness and reach markets in the USA and Canada. The country also provides infrastructure, health for the workforce, efficiency, education, and training, as well the use of available technology [47].

The existence of the North American Free Trade Agreement (NAFTA) between Mexico and these two northern American countries has also favored the establishment of maquiladoras in the northern land of Mexican territory. The state of Chihuahua, for instance, caters for 507 maquiladora

companies, 334 of which are established the city of Ciudad Juárez, representing 65.49 % of the state's total.

In addition, labor force in Mexico from maquiladora industries involves about 2,241,000 work positions, 356,076 of which are established in Chihuahua, and 222,741 concentrate in Ciudad Juárez [47]. In fact, the industrial sector in this city is highly important. For instance, in 2011, it imported 22.6 billion USD in raw materials and exported 43.000 billion USD in finished products [47].

Maquiladoras in the region follow a certain dynamic that, among other aspects, implies on-time delivery of the material flow, either imported or exported. From this perspective, JIT technique can bring several positive results due to the meaningful advantages that it offers. Table 1 thus enlists 31 benefits of JIT identified by [1] and [2]. These benefits may look particularly attractive to production managers or procurement system administrators who seek to implement JIT philosophy in the maquiladoras that they lead.

When managers seek to improve the efficiency and competitiveness of the maquiladoras that they lead, they must primarily and chiefly ask themselves which benefits are important. Since the list may be too broad and long, managers should focus on those benefits that they consider essential. Also, data reduction is necessary to keep the maximum amount of variance but with a shorter list by grouping the 31 benefits reported by Singh and Garg [1] and Kumar [2] into different categories. A factor analysis is thus required. However, benefits in any case are the consequence of several activities known as critical success factors (CSFs). As far as JIT is concerned, some of such CSFs involve management commitment [1, 48–50], quality in the production process [2], education and training [48, 51], and the relationships of companies with their suppliers [9, 52, 53].

2 Methodology

The objective of this research is to assess the extent to which the 31 JIT benefits listed in Table 1 are obtained in the manufacturing sector of Ciudad Juárez, Chihuahua, Mexico. To achieve this goal, managers from different companies were interviewed by means of a questionnaire. Afterward, a descriptive analysis was performed to data collected to recognize the most important benefits reported from a univariate point of view and a factor analysis that allowed for the identification of dimensions, factors, or groups of benefits. The methodology of this research consists of four stages addressed in the following sections.

2.1 First stage: questionnaire design and judge validation

The questionnaire designed includes the 31 JIT benefits reported by Singh and Garg [1] and Kumar [2]. As for its validation, the survey is administered to a panel of 21 judges. In order to seek for its most appropriate understanding in the industrial context of Mexico, judges are determined by considering their expertise and their experience of ten years or more in the industry or academy. The panel is therefore composed of eight production managers (three from the automotive sector, two from the electronic sector, and three from the medical sector), four materials managers (three from the medical sector and one from the automotive sector), three logistics managers (two from the medical sector and one from the automotive sector), as well as six renowned academics specialized in the geographical area to be studied. Feedback provided from the panel allows for the improvement of the instrument, including its writing. The survey is successfully adapted to the regional context of the research, and suggestions are included in a second version of the questionnaire, which is composed of three sections: (1) general objectives of the study, (2) demographic information, and (3) benefits gained from JIT. Respondents must answer the survey in a five-point Likert-based scale [54, 55]. Values for such scale are shown in Table 2.

2.2 Second stage: data collection

Ciudad Juárez currently reports 324 manufacturer companies importing raw material and exporting finished products. However, the following inclusion criteria are employed to define the sample for this research.

- Only companies that import raw materials and export finished products are included.
- These companies ought to rely on a supply chain or materials department.
- Only companies with a well-established JIT-based system are considered. That is, companies included in the sample have been implementing JIT for more than 5 years.

The final questionnaire is administered to manufacturing companies located in Ciudad Juarez, Chihuahua, Mexico, from January 15 to May 25, 2013. The instrument is also provided in three different ways depending on the availability of managers. On the one hand, a hard copy of the survey is delivered to 200 managers after previously established appointments. Companies are visited in three different occasions to obtain the answered questionnaire; but also, 328 electronic surveys are delivered via e-mail.

Table 2 Used scale for questionnaire response

Value	Description
1	Not important
2	Less important
3	Regularly important
4	Important
5	Very important

On the other hand, the questionnaire is also e-mailed. Possible managers and responders are invited three times to collaborate every 2 weeks from the moment they received the questionnaire the first time. Finally, this research also relied on a specialized platform, and the hyperlink from the questionnaire is sent to possible respondents three times.

2.3 Third stage: questionnaire validation and descriptive analysis

The descriptive analysis of data collected is carried out by building a database on SPSS21.0® software. The first instance in the validation process is rational validity, and it is performed with literature reviewed [56] and implemented during the questionnaire creation process.

Before using data, several tests are carried in order to detect missing values, and since data are represented in an ordinal scale (Likert), these missing values are replaced by the median value [57–59] of the item as a measure of central tendency. Similarly, a standardization process is carried out to detect outliers or extreme values, considering only as standardized absolute values those higher than 3.3 [60–62]. Moreover, a statistical survey validation is performed by calculating the Cronbach's alpha coefficient to determine internal consistency [59, 63–66]. A minimum acceptable value for it is 0.8. However, tests are conducted to determine whether the coefficient could be improved by removing certain elements (benefits assessed), since certain items can be explained by others due to high levels of collinearity between them.

In the descriptive and univariate analysis carried out, the median value from every benefit is estimated as a measure of central tendency, since elements (benefits) are assessed by means of an ordinal scale [61, 67–71]. A high median value hence indicates that the benefit is always obtained according to surveyed persons, while a low value implies that the benefit is not obtained. Likewise, interquartile range (IR) values are obtained as a measure of dispersion. IR stands for the difference between the third and first quartile [9, 54]. Therefore, while a high IR value indicates no consensus regarding the value and thus importance of a given benefit, a low IR value implies great consensus among respondents concerning the significance of that same benefit.

2.4 Fourth stage: factor analysis

Statistical tests are also carried out with a screened and validated database. Such tests are performed to determine the feasibility of a factor analysis. The first test aimed to obtain the Kaiser-Meyer-Olkin (KMO) index, which is a measure of sampling adequacy. KMO index is useful to determine whether the partial correlations among variables are small, considering values between 0 and 1. A value close to 1 indicates that a factor analysis is appropriate [72, 73]; however, this study established 0.8 as a minimum cutoff value [56, 73].

Similarly, the Bartlett's sphericity test is carried out. The test uses the correlation matrix of the analyzed benefits to determine similarity to an identity matrix, in which case the test would indicate that the factorial model is inappropriate. The statistics of Bartlett are obtained from a χ^2 transformation, using the determinant from the correlation matrix. Therefore, the P value and degree of freedom in the test are used to determine the feasibility of the factor analysis [65, 66].

Finally, this research relies on a factor analysis using the method of principal components and a varimax rotation, since the new generated factors are independent of each other and maximize the variance extracted [56]. This makes the interpretation of data much easier. The number of iterations is conditioned at 100 to generate a result. Similarly, the number of factors to be considered equals the number of eigenvalues of the correlation matrix, which were greater than the unity [9, 73].

3 Results

3.1 Sample description

In total, 144 of the 166 questionnaires collected are considered valid. From these 144 surveys, 39 are obtained by means of interviews, 36 are received by e-mail, and 69 are collected from the electronic specialized platform.

Table 3 depicts the different industrial sectors surveyed as well as the positions occupied by respondents. The medical sector is the most surveyed, with 56 responders, while the automotive sector holds the second place. The increased automotive sector in Ciudad Juarez has to do with the large number of manufacturers supplying companies such as Ford, GM Company, and Chevrolet. Also, third and fourth places are held by the electric/electronic and aeronautical sectors, respectively, while the packaging sector reports the lowest occurrence in the

Table 3 Industrial sectors interviewed and work positions of respondents

Industrial sector	Managers from			Total
	Production	Materials/ purchasing	Logistics	
Medical instruments	16	25	15	56
Automotive	18	10	2	30
Electronic/electric	2	16	4	22
Aeronautical	5	10	6	21
Plastics	2	3	1	6
Metals	1	1	2	4
Communications	0	1	2	3
Packaging	0	2	0	2
Total	44	68	32	144

Table 4 Gender and years of experience of respondents

Years in job	Gender		Total (percentage)
	Male	Female	
2–3 years	31	27	58 (40.85 %)
3–5 years	26	18	44 (30.99 %)
5–10 years	21	5	26 (18.31 %)
>10 years	10	4	14 (9.85 %)
Total	88	54	142 (100 %)

survey. However, considering the low presence of this sector in the region, two questionnaires obtained seem acceptable.

According to Table 3, 68 responders hold positions of managers in a materials or purchasing department. These managers are perfectly acquainted with the procurement process (raw materials supply, in this case) of the companies where they work. Likewise, 44 responders are managers of production processes who are familiar with the internal movement of material. Finally, 32 responders hold logistics management positions.

Table 4 illustrates the years of experience of respondents in their current position as well as their gender. In this case, 88 responders are male while 54 are female managers. Note that two responders do not inform of their gender or work experience, which is why the total number of participants is 142. In addition, 58 participants or 40.85 % of them had 2–3 years of experience in their current position, while 44 people or 30.99 % of the sample reported 2–3 years. Likewise, note that 40 respondents from two categories have more than 5 years of working experience, which represents 28.17 % of the sample. All this information supports reliability of data collected, since it indicates the level of experience from managers in their current job positions. Everybody in the sample can hence be considered as an expert in his/her field.

3.2 Statistical validation of the questionnaire

A validation process is carried out to data collected before its use. In this case, the value of the Cronbach's alpha coefficient is 0.961 for the 31 benefits analyzed. However, results from that index value are compared with the Spearman-Brown coefficient (equal length and unequal length) and the Guttman split-half coefficient. Table 5 illustrates indices obtained from the validation process, and they all indicate that data collected from the questionnaire is valid. All indexes show values higher than 0.8, the minimum cutoff value established in the methodology section.

3.3 Univariate analysis

Table 6 shows the univariate analysis carried out for the 31 JIT benefits previously listed. They appear sorted in descending order according to their median values. Nevertheless, note that the median value for every benefit is still higher than 3, a regular value according to the scale used. This indicates that all benefits are obtained after a successful JIT implementation in the maquiladora industry of Ciudad Juárez, Mexico.

Table 5 Validation and reliability statistics

Cronbach's alpha	Part 1	Value	0.948
		N of items	16
	Part 2	Value	0.952
		N of items	15
	Total *N* of items		31
Correlation between forms			0.895
Spearman-Brown coefficient	Equal length		0.945
	Unequal length		0.945
Guttman split-half coefficient			0.945
Cronbach's alpha (whole)			0.961

It can also be noted from the table that the lowest IR values are indicated by an asterisk (*). They belong to benefits occupying places 20, 30, and 31. This information demonstrates concordance between the measure of central tendency and the interquartile range values, since low values in medians indicate absence of agreement from responders. Similarly, low values in IR indicating consensus among responders are indicated with the symbol (‡). They concern benefits holding the first, second, and fourth paces. This shows agreement among responders on the fact that *Increased process efficiency*, *Improved worker motivation*, and *Increased teamwor*k are truly reached by managers in the maquiladora sector after JIT implementation.

Table 6 equally shows that *Increasing process efficiency* holds the first place among the classification, which indicates that responders consider it as the most frequently benefit obtained in the maquiladora industry, despite the fact that it showed only nine quotations in literature. However, it is also important to notice that the same first place was previously occupied by *Increased productivity* in Table 1, while it is ranked seventh in Table 6. This shows little similarity between the literature review and the findings from this research as far as this benefit is concerned. Nevertheless, it must be born in mind that benefits in Table 1 were the report of literature review from around the world, while Table 6 stands for the specific case study of Mexican maquiladoras in Ciudad Juárez.

Similarly, the second place in Table 6 is occupied by *Improved worker motivation*, a benefit for the human factor. However, the same benefit was ranked third in Table 1. In other words, the benefit changed one place, suggesting consistency between maquiladoras in Ciudad Juárez and the literature review. Similarly, *Increased product quality* holds the third position in Table 6, while in Table 1. it was ranked second, and this indicates consensus between literature and respondents of maquiladoras in Ciudad Juarez.

Table 6 Descriptive analysis

Benefit	Percentiles			RI
	25	50 Median	75	
1.Increased process efficiency	3.62	4.36	4.94	1.33‡
2.Improved worker motivation	3.51	4.31	4.92	1.41‡
3.Increased product quality	3.45	4.26	4.89	1.43
4.Increased teamwork	3.48	4.25	4.87	1.40‡
5.Increased inventory turnover	3.44	4.23	4.86	1.42
6.Reduced inventory	3.38	4.22	4.88	1.50
7.Increased productivity	3.42	4.21	4.86	1.44
8.Manpower cost reduction	3.38	4.20	4.85	1.46
9.Paperwork reduction	3.39	4.20	4.85	1.46
10.Established cost reduction	3.39	4.18	4.83	1.44
11.Increased financial profit	3.37	4.17	4.83	1.46
12.Reduction in part numbers	3.32	4.15	4.83	1.51
13.Better supplier-customer relationships	3.33	4.15	4.81	1.48
14.Rapid responses to changes in engineering	3.38	4.15	4.79	1.42
15.Increased process quality	3.35	4.15	4.80	1.46
16.Increased communication	3.33	4.14	4.81	1.48
17.Reduced movement distances	3.32	4.13	4.78	1.46
18.Less overhead	3.32	4.10	4.77	1.45
19.Reduced lead time production	3.32	4.10	4.76	1.44
20.Reduction of work in process (WIP)	3.18	4.10	4.79	1.60*
21.Reduction of waste and rework	3.28	4.09	4.77	1.50
22.Improved competitiveness	3.30	4.09	4.77	1.47
23.Increased use of resources	3.27	4.06	4.74	1.47
24.Purchase of reduced lot sizes	3.18	4.05	4.76	1.58
25.Increased innovation	3.20	4.01	4.72	1.51
26.Increased process flexibility	3.16	4.00	4.75	1.59
27.Integration of different activities in manufacturing	3.17	4.00	4.73	1.56
28.Reduced classifications of positions	3.10	3.89	4.66	1.56
29.Product cost reduction	3.09	3.89	4.66	1.57
30.Reduction in materials handling	3.02	3.87	4.68	1.65*
31.Reduced space requirements	2.96	3.80	4.60	1.64*

On the other hand, *Increased teamwork* holds the fourth place in Table 6. Along with *Improved worker motivation* (holding the second place), its position in this ranking suggests that JIT benefits for human factors are important to the Mexican maquiladora industry. However, *Product cost reduction*, *Reduction in materials handling*, and *Reduced space requirements* hold the last places in the same table, which shows inconsistency with the ranking of JIT benefits from Table 1, where they were positioned among the first ten places.

As for low IR values (‡) from the table, it is easy to observe that they correspond to those benefits having the highest median values, which are *Increased process efficiency*, *Improved worker motivation*, and *Increased teamwork*. Therefore, they are not only considered as the most important JIT benefits, but they also reached consensus among respondents regarding their degree of achievement in the maquiladora sector. The relationship between these median and IR values also shows agreement in the maquiladora sector of Ciudad Juarez regarding the JIT benefits achieved in process efficiency and human factors (motivation and teamwork).

3.4 Factor analysis

Prior to the factor analysis, feasibility tests were executed. After such analysis, the determinant for the correlation matrix was 8.24E−013, which is a value very close to 0. This suggests high collinearity among benefits, which indicates feasibility. Table 7 illustrates results from the KMO and Bartlett's test, from which it is concluded that that the factor analysis is

Table 7 KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.95
Bartlett's test of sphericity	Approx. chi-squared	3668.286
	Degree of freedom	465
	Significance	0.00

feasible, since KMO is higher than 0.8—the minimum cutoff value established—and significance for Bartlett's test is acceptable.

Four factors were found with the factor analysis. They explain 67.272 % of the variance of original data, which is enough percentage for the purpose of this research. Table 8 illustrates the eigenvalues, the percentages of variance, and the cumulative variance for these four factors.

Table 9 shows the rotated component matrix with their factor loadings, the items (benefits) integrating every factor, and a proposed name for these factors, which are further described below.

Benefits in inventory management This factor is integrated by seven items that are all related to inventory management and materials handling. Moreover, it explains 18.417 % of the total variance of data, although such result is not surprising, since improved inventory management is the main goal of JIT philosophy. Such results are similar to those reported in [48, 52, 74, 75] in the sectors of maquiladoras and cement.

Benefits in production process This second factor is integrated by 13 benefits, and it explains 17.995 % of the total variance of data. Materials are moved along the production process within companies, and their proper administration is crucial, because it improves the use of resources and consequently favors higher productivity and efficiency in production processes. This simultaneously reduces lead times, provides with fast responses to costumers through agile changes in engineering, and decreases work in process by integrating or joining different activities in production lines. Similar findings were reported in terms of process quality benefit by [2, 48], agile manufacturing process by [76], productivity by [19], and work in process reduction by research from [77].

Benefits in human resources It is integrated by five benefits related to human factors and explains 16.961 % of the total variance contained in the 31 benefits. JIT benefits in human resources seem to be crucial to managers in the maquiladora sector. However, the fact that this factor holds the third and not the second or first place may be surprising, especially when two JIT benefits for human resources actually hold the first two places in the univariate analysis. However, little difference can be perceived from the factor analysis between this factor and the previous two.

As for similar findings described in literature, research from [1] reported increased motivation from workers in the Indian industry after JIT implementation, while other research works [48, 78] reported that empowerment was granted to workers after an adequate training and education process in Mexican and Australian industries. Similarly, research in [79] addressed JIT benefits in flexibility and production control, while authors in [48, 78] addressed communication between organizational levels in the industry context. All these benefits are crucial for an agile material flow.

Economic benefits This factor is composed of five benefits associated with the economic performance of companies, and it explains 13.90 % of the total variance of data. Economic benefits seem to be the last reason to a JIT implementation according to the multivariate analysis, although JIT initially focuses on cost reduction [19, 80]. Moreover, it was observed from the univariate analysis that three benefits associated to cost reduction rank among the first 11th places. A highest position was expected for this factor; however, the maquiladora industry in Mexico may be a very special sector. The relationship between JIT and the financial income of companies has also been reported in [76, 80, 81] in different sectors.

4 Discusion and conclusions

This article proposes a literature review of 31 benefits obtained after JIT implementation. Literature consulted for the research indicated that the most important JIT benefits were increased efficiency, productivity, worker motivation, and teamwork. However, to find consistency between this literature review and the reality of manufacturing companies in

Table 8 Total variance explained

Initial eigenvalues			Rotation sums of squared loadings		
Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
17.181	55.423	55.423	5.709	18.417	18.417
1.455	4.692	60.115	5.578	17.995	36.411
1.204	3.883	63.998	5.258	16.961	53.372
1.015	3.274	67.272	4.309	13.900	67.272

Table 9 Rotated matrix with factors

Benefit	Factor loadings	Factor name
Purchase of reduced lot sizes	0.755	Benefits in inventory management (var. 18.417 %)
Increased inventory turnover	0.65	
Improved competitiveness	0.614	
Reduced inventory	0.56	
Reduction in materials handling	0.527	
Reduced movements distances	0.512	
Increased use of resources	0.503	
Increased productivity	0.705	Benefits in production process (var. 17.995 %)
Increase product quality	0.681	
Increasing process efficiency	0.676	
Reduction in waste and rework	0.675	
Reduced lead time production	0.607	
Increased quality process	0.545	
Paperwork reduction	0.665	
Rapid responses to changes in engineering	0.632	
Reduction in part numbers	0.63	
Reduction of work in process (WIP)	0.583	
Reduced classification of positions	0.548	
Integration of different activities in manufacturing	0.538	
Better supplier-customer relationships	0.509	
Improved worker motivation	0.656	Benefits in human resources (var. 16.961 %)
Empowerment to workers	0.633	
Increased process flexibility	0.603	
Increased teamwork	0.553	
Increased communication	0.547	
Established cost reduction	0.728	Economic benefits (var. 13.900 %)
Increased financial profit	0.723	
Manpower cost reduction	0.675	
Less overhead	0.638	
Product cost reduction	0.524	

Ciudad Juarez, Mexico, these 31 benefits were included in a questionnaire eventually administered to the companies that collaborated in the research.

A total of 144 questionnaires were therefore analyzed, and based on the univariate analysis, little difference was found between the first benefits reported in the literature review and the first reported in this research of Mexican maquiladoras. However, significant differences were found regarding benefits that occupy last places in this research.

Similarly, a factor analysis was carried out to the 144 surveys to reduce the information, and it was concluded that four factors could explain 67.272 % of the total variance of data. These factors were *Inventory management*, *Production process*, *Human resources*, and *Economic benefits*.

Finally, it can be stated that results from this research bring the following industrial implications to the Mexican maquiladora sector:

- Due to the high amount of raw materials imports and final product exports, JIT philosophy is currently a solution for maintaining adequate production standards in a globalized market. Moreover, it has been usually recognized as a strategy for maquiladoras in the twenty-first century [82].
- JIT forces maquiladoras to have low inventory levels and reduce materials handling, which in turn reduce handling cost. This helps focus on high quality of processes and products and fast response to customers [83].
- Performance increases in production processes as a result of JIT implementation, since resources utilization rates and quality are improved, while deliveries are made on time. Similar findings were reported in [9, 76] in American companies using a structural equation model to find relationships between JIT strategies variables and financial income.
- Human resource satisfaction and motivation are two benefits that managers from maquiladoras usually seek. Highly qualified personnel improve the production process, and therefore, it helps gain greater economic profits for the company.

5 Future research

Future research will propose a structural equation model that would associate factors here reported to measure their impact one on another. Human resource benefits will be considered the independent latent variable, while economic benefits will be viewed as the dependent latent variable.

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