



JUST-IN-TIME: REVIEW OF EMPIRICAL STUDIES

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ABSTRACT

This study is a review of literature and empirical studies on the subject of Just-in-Time (JIT), conducted by a selection of articles published in international journals included in the ISCTE Business School Ranking, released since the 1980s to the present days. The purpose of this research was to compare the key features and benefits of JIT reported by the theory with the practice reported by companies in empirical studies already conducted. In addition, the percentage of use and the importance of JIT in different countries were also analyzed. A small case study of a Japanese enterprise – Mazda Motor Corporation – was also conducted in order to complement the investigation on the subject. As a result, it became clear that there were companies using JIT philosophy with distinct features and benefits that were not reported in the literature on the subject. The United Kingdom had the highest percentage of JIT use, and in broad terms, JIT was not frequently used in the majority of the countries surveyed. One reason for this can be explained by the fact that companies did not attribute a high degree of importance for JIT practices. This means that the companies analyzed did not implement JIT practices extensively.

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Keywords: JIT, Features, Benefits, Utilization, Case study, Mazda.

Contribution/ Originality

This study contributes in the existing literature because it allows a better perception of JIT philosophy. Through it is possible: to acquire a clear idea of the main benefits and key features of JIT; to identify in the different countries considered the use of in each stage of implementation.

1. INTRODUCTION

Just-in-Time is still a current research topic, as evidenced by recent studies published in scientific journals (Chen and Sarker, 2010; Boysen and Bock, 2011; Jolai *et al.*, 2011; Ohno, 2011; Bala, 2012; Shabtay, 2012; Shabtay *et al.*, 2012; Chung and Choi, 2013; Manavizadeh *et al.*, 2013; Mosheiov and Shabtay, 2013; Rao *et al.*, 2013). This study aims to compare the existing theories on the subject of Just-in-Time (JIT) with the practice reported by companies in empirical studies already conducted. This study intends to contribute to the knowledge about the main characteristics of JIT that have been used in practice reported by empirical studies already conducted, and also, to identify what the main benefits of using JIT stated by the companies using this philosophy. In addition, the percentages of use and the importance of JIT in the countries which collected beneficial data through research on the topic will also be analyzed. A small case study of a Japanese enterprise – Mazda Motor Corporation – is also described in order to complement the investigation on the subject.

This study was conducted through a documental analysis of the literature review, supported by two distinct phases: literature review related to JIT by reference of the main authors of the subject; review of empirical studies about JIT. The period selected for study was the 1980's until the present. This period was selected due to the fact that JIT started to be used by American and European companies from the 1980's.

The main conclusions revealed that there were companies that used JIT with distinct features of the theories and recognized benefits that were not reported in the literature of the subject. The United Kingdom had the highest percentage of JIT use, and in broad terms, JIT was not frequently used in the majority of the countries surveyed. One reason for this can be explained by the fact that companies did not attribute a high degree of importance for JIT practices. This means that the companies analyzed did not implement JIT practices extensively.

2. LITERATURE REVIEW

Just-in-Time (JIT) systems were originally developed by the Toyota Motor Company (Im, 1989). The oil crisis helped many Japanese companies to recognize the need for a new approach to cope with declining economic growth and tougher international competition. Many of these companies decided to adopt Toyota's JIT system after witnessing Toyota's continued growth during this period. In this way, JIT spread rapidly all over Japan (Im, 1989). Between 1982 and 1983, JIT spread across Canada and Europe mainly through North American multinational divisions. Around the year 1985, JIT had extended to Central and South America, even across divisions of these corporations (Hay, 1991). Kalagnanam and Lindsay (1998) justify the adoption of JIT production systems by many firms as a result of the current business environment. This business environment is characterized by intense global competition, with firms competing increasingly not only on the basis of price, but also on quality, product flexibility, and response time.

JIT concept is so wide and complex that it is difficult to find a complete definition of this system. Several authors argue that there is no consensus in the literature about what really constitutes and defines JIT (Billesbach, 1991; Howton *et al.*, 2000; Mia, 2000; Ahmad *et al.*, 2003; Callen *et al.*, 2005; Callen *et al.*, 2008). In fact, the discussion concerning the JIT definition still persists and the definitions that were found are much diversified and sometimes even confusing. Below are some alternative definitions and points of view for the term that have been published over the years.

Sadhvani *et al.* (1985) considered JIT as a philosophy and specified that it draws upon several existing procedures used in manufacturing, industrial engineering, storage technologies, capacity planning, and quality control. They added that JIT might be applied to all aspects of the business including production, purchasing, and delivery. According to this definition JIT was designed as a technique for inventory management which has as its main goal to produce and deliver goods just in time to be sold. Therefore, is the final product demand that drives the system in order to produce just the right product at the right time in the right quantities. The authors also shared the idea that all inventories are undesirable and should be eliminated or minimized.

Kim *et al.* (1988) also agreed to the idea that JIT is a philosophy that affects the whole operating system of the company. The authors argued that JIT is not a mere inventory control technique, but a manufacturing system that try to enhance quality and lower costs through the reduction of inventories and shortening lead times.

Hay (1991) also affirmed that JIT is a production philosophy, a philosophy of eliminating waste in the overall production process from the procurement stage all the way up to the distribution stage. In his opinion, JIT is a set of basic rules that establish the proper way to carry out production and the proper way to negotiate with suppliers and customers, which leads to production efficiency.

Cobb (1991;1992) also defined JIT as a management philosophy that aims for the elimination of waste from all parts of the manufacturing cycle, from product design to product delivery. Through a process of continuous improvement, all activities which do not add value to a product should be eliminated and the utilization of the minimum amount of materials must be used, taking into account the market requirements. According to the author, this process has major effects for the design, operation and use of management accounting systems.

Fullerton and McWatters (2002) defined JIT as a manufacturing philosophy that emphasizes excellence through the constant elimination of waste and improvement in productivity. The authors added that JIT requires a decision-making system that evaluates the changes in quality, setup times, defects, rework, and throughput time. Despite the fact that there is some confusion between the different arguments above about how to define JIT, however, the majority of the authors agreed that JIT is a philosophy that can be applied in all kinds of companies. In relation with the elements that constitute JIT it is unclear as to what the main components of the concept are (Billesbach, 1991). Callen *et al.* (2005;2008) mentioned that there is no formally accepted definition in the literature about the features that stabilize JIT. The key element of JIT phenomenon is called

Elimination of Waste and was removed from all the seven elements and placed higher, under which all the others elements fit in below. The remaining elements are techniques to achieve the Elimination of Waste. There are five elements: uniform factory load, set-up time reduction, machine/work cells, pull system (Kanban) and JIT purchasing; which were grouped into one, denominated Production Flow. All these elements reveal how the operating process proceeds in the passage of an operation to the next. The second element is Quality. It is important to note that Quality itself does not require JIT, but JIT requires Quality. Employee Involvement is the last element which needs to be infused in each element so that JIT can work. Six of these elements are related within the organization and one, JIT purchasing, is related with the exterior (Hay, 1991).

Through the seven essential elements identified above by Hay (1991), it is possible identify the main features of JIT: Uniform Factory Load; Set-up Time Reduction; Machine/Work Cells; Pull System (Kanban); JIT Purchasing; Product Design; Process Design; Supplier Quality; Workforce flexibility; Greater participation and responsibility; Continuous improvement; Jidoka and Multifunction Employees. After a successful implementation of the elements and characteristics of JIT, companies can experience the benefits and advantages as those which were described by the various interpretations on JIT. Based on the analysis of several studies that documented the success of JIT, the following benefits were reported: Reduction in stock holding costs (by minimizing raw materials, work-in-process and finished goods inventories) (Sadhvani *et al.*, 1985; Kim *et al.*, 1988; Hay, 1991; Norris *et al.*, 1994; Howton *et al.*, 2000; Bala, 2012; Rao *et al.*, 2013); Reduction in costs of other inventory related costs (by reducing rework, controls scrap and warranty costs) (Sadhvani *et al.*, 1985; Kim *et al.*, 1988; Hay, 1991; Norris *et al.*, 1994; Howton *et al.*, 2000; Fullerton *et al.*, 2003); Improves product quality and production quality (Kim *et al.*, 1988; Hay, 1991; Norris *et al.*, 1994; Yasin *et al.*, 1997; Fullerton *et al.*, 2003; Nicolaou, 2003; Mia and Winata, 2008); Shorter lead times (Norris *et al.*, 1994; Yasin *et al.*, 1997; Fullerton *et al.*, 2003; Shabtay, 2012); Quicker response to customer and market demands (Hay, 1991; Norris *et al.*, 1994; Fullerton *et al.*, 2003; Nicolaou, 2003); Improvement of inventory turnover (Hay, 1991; Norris *et al.*, 1994; Huson and Nanda, 1995; Balakrishnan *et al.*, 1996; Fullerton *et al.*, 2003; Nicolaou, 2003; Chen and Sarker, 2010; Boysen and Bock, 2011); Decrease in set-up times (Yasin *et al.*, 1997; Fullerton *et al.*, 2003; Nicolaou, 2003); Increase Productivity (Sadhvani *et al.*, 1985; Yasin *et al.*, 1997; Fullerton *et al.*, 2003; Jolai *et al.*, 2011; Ohno, 2011; Shabtay *et al.*, 2012; Chung and Choi, 2013; Manavizadeh *et al.*, 2013; Mosheiov and Shabtay, 2013).

3. REVIEW OF EMPIRICAL STUDIES

Twenty-six empirical studies conducted in different countries were reviewed: Cheng (1988); Ahmed *et al.* (1991); Billesbach (1991); Cobb (1992); Norris *et al.* (1994); Huson and Nanda (1995); Matsuura *et al.* (1995); Balakrishnan *et al.* (1996); Kim and Takeda (1996); Yasin *et al.* (1997); Kalagnanam and Lindsay (1998); Durden *et al.* (1999); Hoque (2000); Howton *et al.* (2000); Mia (2000); Fullerton and McWatters (2002); Kinney and Wempe (2002); Ahmad *et al.* (2003); Fullerton *et al.* (2003); Nicolaou (2003); Abdel-Maksoud *et al.* (2005); Callen *et al.* (2005);

Matsui (2007); Callen *et al.* (2008); Maiga and Jacobs (2008); Mia and Winata (2008). All studies were organized into groups and compared in order to emphasize what they had in common, in accordance with the benefits and main features of JIT. The studies that showed the percentage of JIT use and the degree of JIT importance were analyzed according to the country. In regard with the benefits of JIT, from the twenty-one studies that reported benefits, sixteen studies identified the same eight JIT benefits already established in the literature. According to Figure 1 the benefit which was the most cited was the reduction in stock holding costs (17% was reported).

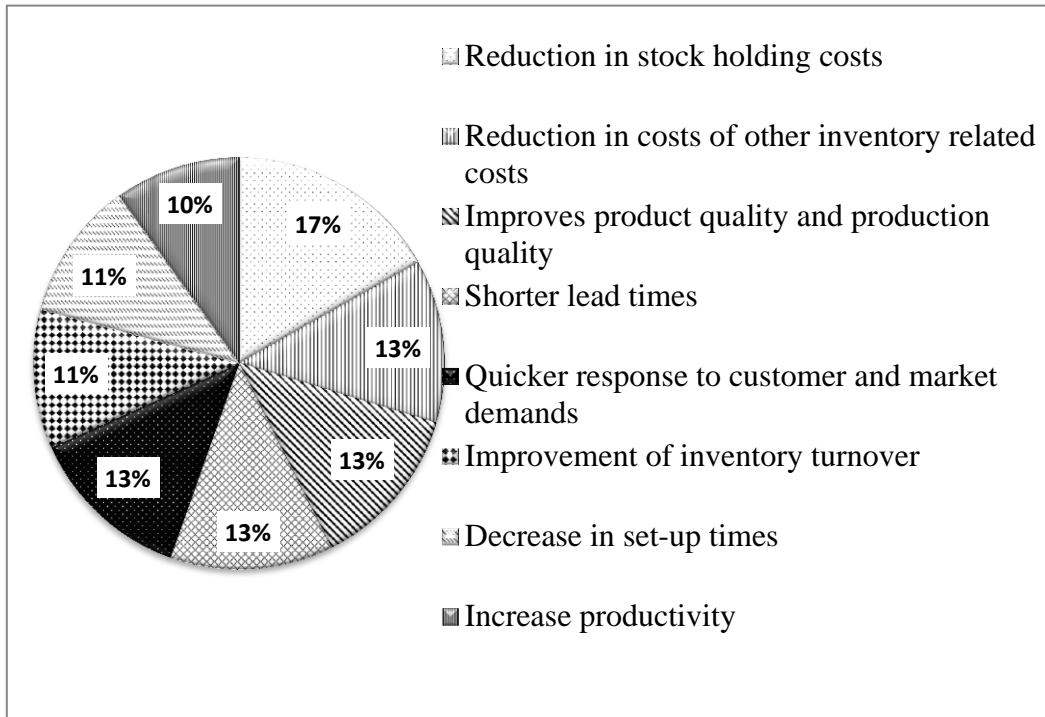


Figure-1. Benefits of JIT reported by theory

Source: elaborated by the authors

On the other hand, the least cited was the increase productivity (10% reported). For all other benefits, the companies did not attribute a clear level of importance that permitted a perfect distinction between them. We can conclude that all of the stated benefits are important, but the degree of importance depends, perhaps, on the goals of each company.

Apart from the JIT benefits reported in the literature, there are also other benefits that were found in the empirical studies. From the twenty-one studies that reported JIT benefits, sixteen studies identified seven different JIT benefits'. From these seven benefits, the three that were most recognized by the companies were (see Figure 2): profitability (26% of JIT benefits reported by empirical studies); increases manufacturing flexibility (21% of JIT benefits reported by empirical studies) and improves competitiveness and efficiency (18% of JIT benefits reported by empirical studies).

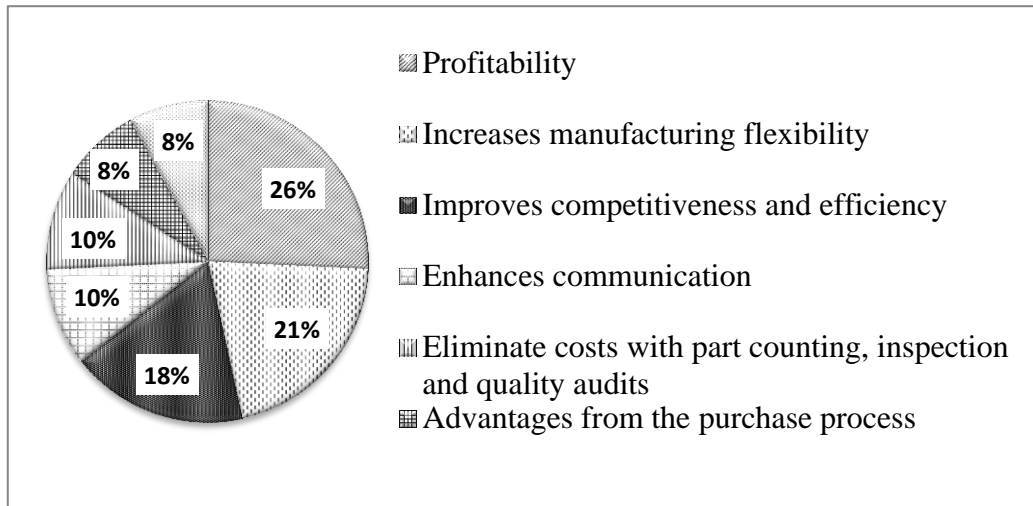


Figure-2. Other benefits of JIT reported by empirical studies

Source: elaborated by the authors

As far as JIT implementation process is concerned, the literature reviewed identified thirteen features associated with phases of production flow, quality and employee involvement. Of the twenty-six articles analyzed, Table 1, Table 2 and Table 3 show fifteen studies that identified those thirteen characteristics per each JIT stage of implementation.

Table-1. The JIT characteristics in a Production Flow stage

JIT characteristics in a production flow stage	Number of studies
Uniform Factory Load	14 (93%)
Set-up Time Reduction	14 (93%)
Machine/Work Cells	15 (100%)
Pull System (Kanban)	12 (80%)
JIT Purchasing	14 (93%)

Source: elaborated by the authors

The studies which reported less JIT characteristics were as follows: [Billesbach \(1991\)](#) of United States reported just 5 characteristics; [Fullerton et al. \(2003\)](#) of United States reported 7 characteristics; and finally, [Cheng \(1988\)](#) of China and [Mia and Winata \(2008\)](#) of Australia both reported 8 characteristics.

Table-2. The JIT characteristics in a Quality stage

JIT characteristics in a quality stage	Number of studies
Product Design	12 (80%)
Process Design	14 (93%)
Supplier Quality	11 (73%)

Source: elaborated by the authors

On the other hand, the following studies reported all JIT features: [Kalagnanam and Lindsay \(1998\)](#) of Canada; [Ahmad et al. \(2003\)](#) of Japan, USA and Italy and also [Matsui \(2007\)](#) of Japan. The predominance of Japan can be explained by the fact that JIT began from Japan and had this philosophy well implemented for several years.

Table-3. The JIT characteristics in an Employee Involvement stage

JIT characteristics in an employee involvement stage	Number of studies
Workforce flexibility	8 (53%)
Greater participation and responsibility	9 (60%)
Continuous improvement	9 (60%)
Jidoka	4 (27%)
Multifunction Employees	14 (93%)

Source: elaborated by the authors

Figure 3 shows the average of JIT features identified in the empirical studies by continent: America is represented by the United States and Canada; Europe is represented by United Kingdom and Italy; Asia is represented by China and Japan; and finally, Oceania is represented by Australia. The European continent has the most studies with more JIT characteristics reported, followed by Asia, America and Oceania. As [Hay \(1991\)](#) noted, JIT is a production philosophy that genuinely reached the West.

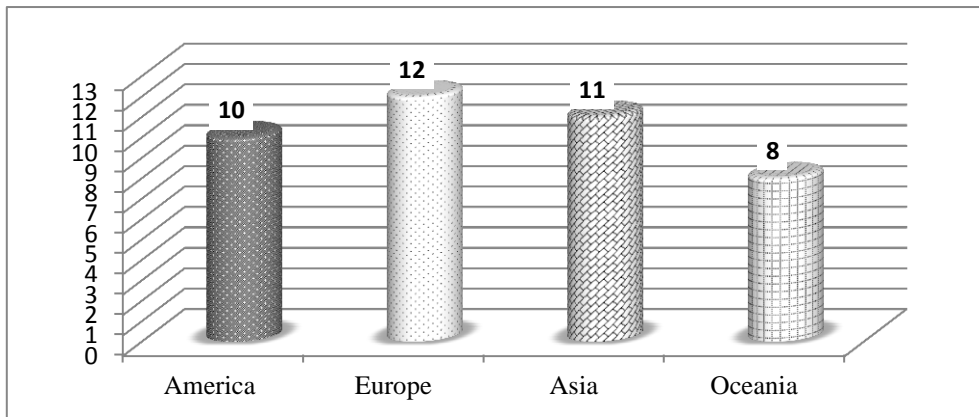


Figure-3. Average of JIT features by continent

Source: elaborated by the authors

Figure 4, Figure 5 and Figure 6 show, in a more detailed way, the average of JIT features found by country in each JIT stage. On average, all countries fully implemented the production flow and quality stage. In fact, several authors agree that the production flow stage is the essence of JIT implementation. Based on this assumption, some studies adopted a narrow definition of JIT to classify whether or not the companies were JIT users or not ([Balakrishnan et al., 1996](#);

Kalagnanam and Lindsay, 1998; Hoque, 2000; Howton *et al.*, 2000; Mia, 2000; Nicolaou, 2003; Callen *et al.*, 2005; Callen *et al.*, 2008).

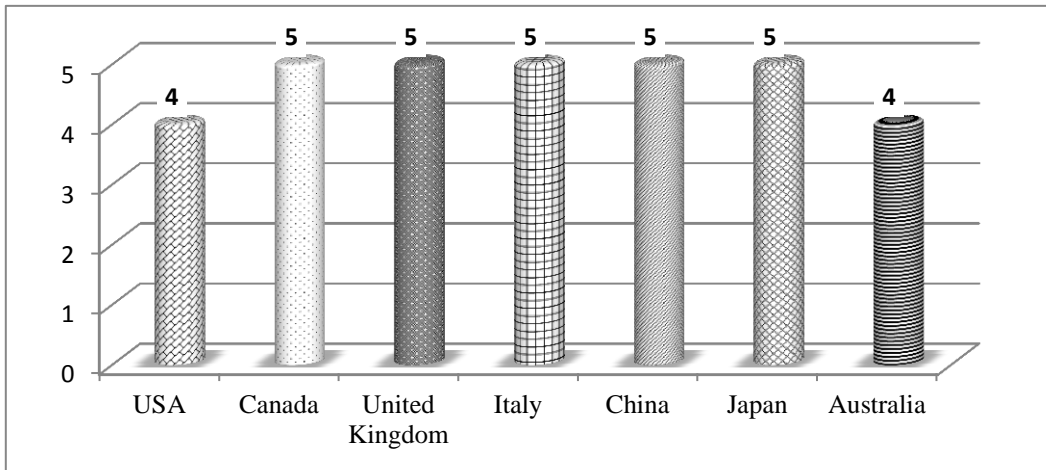


Figure-4. Average of JIT features in a Production Flow stage by country

Source: elaborated by the authors

In regard to the quality stage, the reason is quite similar. There is also a consensus among the authors that the implementation of JIT cannot be possible without quality (Hay, 1991; Selto *et al.*, 1995; Callen *et al.*, 2005; Callen *et al.*, 2008).

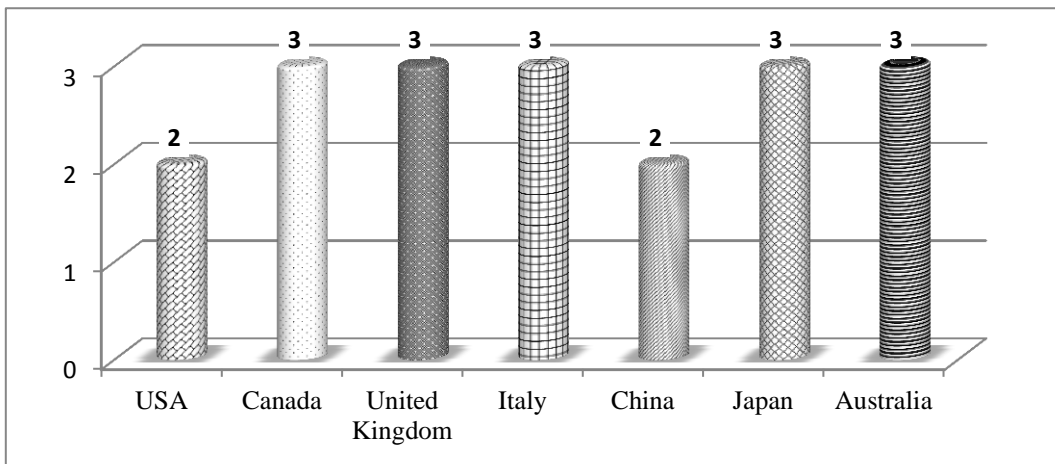


Figure-5. Average of JIT features in a Quality stage by country

Source: elaborated by the authors

On the other hand, the employee involvement stage, on average, showed fewer characteristics in use countries, just 3 in 5. However, Hay (1991) justified this absence of use as being a misunderstanding of western companies about what really constituted this particular JIT element.

He added that this employee involvement stage was something that must be recreated in companies and acculturated in workers for JIT to work.

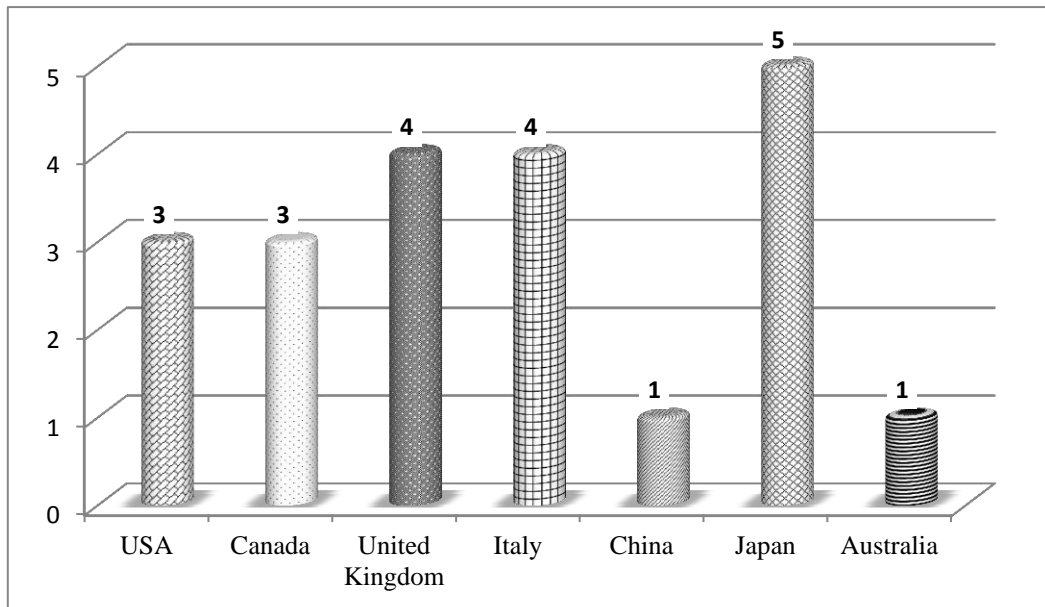


Figure-6. Average of JIT features in an Employee Involvement stage by country

Source: elaborated by the authors

Apart from the features reported in the theories and found in the empirical studies analyzed, some studies reported other features (Kalagnanam and Lindsay, 1998; Durden *et al.*, 1999; Mia, 2000; Fullerton and McWatters, 2002; Abdel-Maksoud *et al.*, 2005; Mia and Winata, 2008): the use of statistical process control (SPC); the use of non-financial performance indicators and the use of management accounting systems (MAS) information.

With regard to JIT utilization, twelve studies from different countries reported the percentage of JIT use among the surveyed companies. The country with the highest percentage of use was the United Kingdom with 81%, followed by Canada with 65%, Australia with 51%, the United States with 48%, Japan with 45%, and Finland with 44%. The country with the lowest percentage of JIT utilization was New Zealand with 38%. This results show that JIT is not frequent use in the majority of the countries surveyed.

4. CASE STUDY: MAZDA MOTOR CORPORATION

The head office of Mazda Motor Corporation was visited as part of this case study. An overview of the Mazda Company was given by a guide along the visit, which was organized into the following seven stages: Entrance Hall, including displays of the latest vehicles; History of Mazda since the 1920s to the present day, with an exhibit of historic cars; Description of the Rotary Engine and exhibition of the racing car that won at Le Mans; Technology, through an explanation of the vehicles manufacturing process; Observation of the Assembly Line Number One, where

multiple models are produced on a single line and observation of the Mazda's private port; Future Section, which displays feature examples of cutting-edge technology; Mazda Museum Shop, where Mazda original goods are on sale. The corporate information provided revealed that the number of employees is 20, 825 people, the domestic sales is 205, 885 units and the export represents 719, 445 units, with North America and Europe being the principal destination of the exports. The plant manufactures over eleven different models, nine are assembled in plant number one – Mazda2, Mazda Verisa, Mazda MX-5, Mazda RX-8, Mazda8, Mazda CX-9, Mazda Biante, Mazda E-series (Bongo Van), Mazda2 (3-door Hatchback) – and the other two – Mazda5, Mazda CX-7 – are assembled in plant number two.

The main propose of the visit was to become aware of the techniques which are used by Mazda Company during its production process and also to discover similarities with the JIT features. During the observation of the assembly line number one it was possible to note the existence of some techniques that correspond with the following JIT features: (1) Uniform Factory Load, characterized by the fact that Mazda Company produces almost all production according to the customers' demand. The stocks represent only thirty percent of the production; (2) Set-up Time Reduction through the existence of a continuous flow that enables the company to reduce their lead time. There were no signals of stoppages during the manufacturing process; (3) Machine/Work Cells which were connected along the whole assembly line. In each cell, the employees (normally two) repeat the same tasks over and over again. They work together and complement the job of each other by the execution of different tasks in different machines at the same time. There is no material handlings because, in each cell, there is only the exactly amount of pieces that are necessary for that spot; (4) Pull System (Kanban) which is evident by the existence of some computers along the assembly line that transmit information about the production of the products/components when needed. It is possible to know continually the pieces that have been used and that need to be replaced in each work cell. There is also the existence of several boards containing information about the results of the production; (5) Product Design by the use of components that fit easily together in an obvious and unique way; (6) Multifunction Employees who are able to realize different tasks at the same time. All the above JIT characteristics reveal that Mazda Motor Corporation has implemented the three JIT stages of JIT implementation. However, when the Company is questioned directly about the use of JIT, the answer is no. This fact may be caused by Japanese culture which is characterized by being extremely reserved and by the existence of a certain pride that makes them deny the use of a system created by a great rival in this case, Toyota Motor Company.

5. CONCLUSIONS

This study intends to contribute to the knowledge about the main characteristics of JIT that have been used in the practice reported by empirical studies already conducted, and also, to identify what were the main benefits stated by the companies using this philosophy. In addition, the

percentages of use and the importance of JIT in the countries which collected beneficial data through research on the topic were also analyzed

In regard to the main characteristics of JIT reported by companies in the empirical studies, thirteen features associated with phases of production flow, quality and employee involvement were identified. Japan is the only country that has the majority of the studies analyzed reporting all the features and stages of JIT. This can be explained by the fact that JIT began in Japan which had this philosophy well implemented for several years before the studies were done. The articles reviewed show that it was the European continent's case that the studies reported more JIT characteristics compared to other continents. In a more detailed analysis, the average of the JIT features found by country in each JIT stage revealed that all countries fully implemented the production flow and quality stage. The majority of the benefits that were cited corresponded with the eight benefits that were reported by each of the theories of which reduction in the stock holding costs was considered the most important of them. The empirical studies also revealed that there was a significant proportion of other JIT benefits which were reported by the companies. Among the seven benefits recognized, the three most cited were: the profitability; increases in manufacturing flexibility; and, improved competitiveness and efficiency. With regard to JIT utilization, the United Kingdom was the country with the highest percentage of use among the different countries. There was an apparent contradiction in regard to JIT utilization in Japan. It was the only country that revealed the use of all JIT features, but at the same time the percentage of use was not as high as expected. However, through the case study carried out about Mazda Motor Corporation it was possible to conclude that the percentage of JIT use in Japan is even higher than the percentage reported by the empirical studies since even a company that says it does not rely on JIT presents the following characteristics of JIT: Uniform Factory Load; Set-up Time Reduction; Machine/Work Cells; Pull System (Kanban); Product Design and Multifunction Employees. According to Professor George Harada of HUE, this fact may be caused by Japanese culture which is characterized by being extremely reserved and by the existence of a certain pride that makes them deny the use of a system created by a great rival in this case, Toyota Motor Company. Through the percentages of JIT utilization it was also possible to conclude that JIT is not frequently used in the majority of the countries surveyed.

The following aspects were considered as being the main limitations of this work: the scope of the study only covered twenty-six articles; most of the studies analyzed were conducted in the same countries which introduced a limitation in terms of geographical and cultural analysis; the existence of only a few recent studies specialized on this issue; the fact that most of the studies analyzed were made in medium and large companies all belonging to the manufacturing sector, which restricts the results because there is no data concerning small enterprises and different sectors of the industry. Overall, this study contributes to a better perception of JIT philosophy. Through this study it is possible, not only to acquire a clear idea of the main benefits and key features of JIT but also, to identify, in the different countries considered, the use of JIT as an entire philosophy and, more specifically, in each stage of implementation. The results found in this study suggest the necessity

of future investigation in the following three main areas: identification of the causes for the differences found between what is presented in the theories as being the characteristic and the benefits of JIT and what is reported by empirical studies already conducted; the concentration of empirical studies about the percentage of JIT utilization, in a limited number of countries, suggesting the necessity of future research in the actual dissemination of this management philosophy worldwide; the fact that there are no studies in small companies and in different sectors of industry, apart from the manufacturing, suggests the necessity of future research on whether the use of JIT is or not associated with company size and sectors of activity.

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