

A Study on Just-in-Time Implementation in Portugal: Some Empirical Evidence

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Abstract

The objective of this paper is to find how far the Just-in-Time system is being implemented by Portuguese manufacturing firms, as well as assessing its perception and its potential benefits by managers. First, several studies about the implementation of the Just-in-Time system in various countries over the past 25 years are reviewed, and then the descriptive survey research is reported. Data were collected from a mail questionnaire sent to a few hundred firms in Portugal. The findings show that the surveyed firms view the Just-in-Time system as a way to reduce inventories, to increase quality, and to eliminate waste. Despite this good perception, less than 6% of the surveyed firms have the necessary conditions to successfully implement a Just-in-Time system. A significant practical implication of this study is that Portuguese firms should use Just-in-Time as a philosophy rather than as a solution for operations-related problems. Another contribution is to point out the most common difficulties for its implementation, so that Portuguese firms that want to do it can be prepared to overcome those difficulties.

Keywords: just-in-time, descriptive survey

Introduction

Just-in-Time is a philosophy of operation that seeks to utilize all resources in the most efficient way. This is accomplished by eliminating waste, i.e., anything that does not add value to the product. The Just-in-Time system was developed in Japan by Toyota (Monden, 1998), and was also adopted by other automobile and electronic manufacturers in Japan. In the late 1970s U.S. manufacturers became more and more interested in this manufacturing

management philosophy, and since the 1980s many non-Japanese firms began adopting it. Indeed, as regional and global competition increases, efficient operations are paramount.

As early as 1982, Schonberger (1982a), identified higher quality, lower inventory levels, improved throughput times and shortened response times as some of the benefits of Just-in-Time. According to Inman and Mehra (1993), the main advantages of the Just-in-Time philosophy are lower costs, better quality, and higher competitive advantage. But the most consistent benefit found in empirical studies is a reduction in inventory levels and/or an increase in inventory turnover (Toni and Nassimbeni, 2000; Cua et al., 2001; Kaynak and Pagán, 2003).

There are, however, some conditions or pre-requisites to successfully implement this management philosophy, such as quick and economic setups (to allow small lot sizes) and a uniform production rate (to ensure schedule stability). These conditions are presented by several authors (e.g., Golhar and Stamm, 1991; Zhu et al., 1994; Ahmad et al., 2004; Schonberger, 2007), adding other elements such as a pull control system, flexible employees, preventive maintenance, supplier long-term relationships, and quality circles. Golhar and Stamm (1991), conducted an extensive literature review and identified four basic principles of the Just-in-Time management philosophy: (i) elimination of waste, (ii) employee involvement, (iii) supplier long-term relationships, and (iv) total quality control. These principles, and the implementation conditions, provided the foundation for the survey research design presented in Section 3.

Several studies on Just-in-Time practices and its implementation have been conducted, first in developed countries (e.g., United States, United Kingdom, Japan, Australia, Canada) and later in developing countries (e.g., Mexico, Egypt, Ghana, India, Malaysia, Saudi Arabia). This paper presents a field study of Just-in-Time in Portugal. Its objectives are to report the results of a descriptive survey research (Forza, 2002) conducted in Portugal to assess local implementation of Just-in-Time practices.

An important contribution of this paper is that it adds to the empirical database of Just-in-Time practices and its implementation in Portuguese firms, allowing one to know how manufacturing managers are aware of this management philosophy and its potential benefits. Another contribution is to find the most common difficulties for Just-in-Time implementation, so that Portuguese firms can be prepared to overcome them. As this study is exploratory in nature, no hypotheses are presented for rigorous statistical testing. Instead, some preliminary findings with regard to the above issues are highlighted.

The paper is divided as follows. Section 2 presents a short review of empirical studies of Just-in-Time practices in several countries. In Section 3, a description of the research methodology (sample, method, questionnaire design, etc.) is presented. The analysis of the results of the survey, using descriptive statistics, are presented in Section 4, and Section 5 contains the main conclusions and some recommendations for practitioners considering the use of Just-in-Time in Portugal.

Literature Review

As previously mentioned, in the late 1970s, early 1980s many non-Japanese firms began adopting the Just-in-Time philosophy. Subsequently, many studies dealing with Just-in-Time implementation in several countries have been conducted and reported.

Table 1 presents a non-exhaustive list of such empirical studies, with the countries sorted in alphabetical order. These studies were collected searching international bibliographic databases (such as Academic Search Complete and Business Source Complete - EBSCO, EconLit, Economia y Negocios, Regional Business News, Science Direct, Emerald, Ingenta Select, and Scopus) using the search capabilities of those databases (by word in the subject, abstract or title fields). A search on the World Wide Web using Google Scholar complemented the previous list of references.

As can be seen in Table 1, the first studies date back to 1982 and 1983, and were conducted in the United States and the United Kingdom by Schonberger (1982b), and White (1983), respectively. These two countries deserved a lot of attention over the years, especially the United States, and other studies followed.

Table 1 - Studies relating to Just-in-Time implementation in several countries.

Country	References
Australia	Buxey and Petzall (1991); Clarke and Mia (1993); Power and Sohal (2000)
Canada	Handfield et al. (1993); Deshpande and Golhar (1995)
China	Pheng and Min (2005)
Egypt	Salaheldin (2005)
Ghana	Gyampah and Gargeya (2001)
Hong Kong	Cheng (1988)
India	Chandra and Kodali (1998); Kumar et al. (2004); Laosirihongthong and Dangayach (2005); Wakchaure et al. (2006)
Italy	Bartezzaghi et al. (1992)
Japan	Matsui (2007)
Korea	Lee (1992)
Malaysia	Ahmed et al. (2004)
Mexico	Lawrence and Hottenstein (1995); Lawrence and Lewis (1996)
Saudi Arabia	Andijani and Selim (1996)
Singapore	Hum and Ng (1995); Min and Pheng (2005)
Spain	Zantinga (1993); Gonzalez-Benito and Spring (2000)
Sweden	Engstrom et al. (1996)
Turkey	Oral et al. (2003); Polat and Arditi (2005)
United Kingdom	White (1983); Voss (1984); Voss and Robinson (1987); Mould and King (1995); Oliver et al. (1996); Waterson et al. (1999)
United States	Schonberger (1982b); Plenert (1985); Celley et al. (1986); Crawford et al. (1988); Im and Lee (1989); Gilbert (1990); Ahmed et al. (1991); Billesbach et al. (1991); Freeland (1991); Young (1992); White (1993); Huson and Nanda (1995); Sriparavastu and Gupta (1997) Wafa and Yasin (1998); White et al. (1999); Lau (2000); Kaynak and Pagán (2003); Yasin et al. (2003)
US and Japan	Womack et al. (1990); Cusumano and Takeishi (1991); Daniel and Reitsperger (1991); Nakamura et al. (1998); Aghazadeh (2003)
West Germany	Wildemann (1988)

In the 1980s, besides the several studies on the U.S. and the U.K., there were also papers about the implementation of Just-in-Time in West Germany and Hong Kong in 1988. Most of the studies reported in the 1990s were conducted in developed countries, such as Australia, Canada, Italy, Korea, Spain, Sweden, etc. Similar studies in developing countries (China, Egypt, India, Mexico, Turkey, etc) are more recent, most of them already in the 21st century. Most of the reported studies provide empirical evidence about Just-in-Time implementation and practices.

Research Methodology

A survey questionnaire was used to obtain the data used in this research. This methodology has been used by several researchers in global manufacturing planning and control (e.g., Handfield and Withers, 1993).

Convenience sampling (Forza, 2002) was selected, and the electronic, metal parts, and paint manufacturers (ISIC codes 3210, 3813, 2891, 2422, 3521) were chosen due to the availability of data that allowed us to send them a postal questionnaire.

The questionnaire was sent to the manufacturing or general manager of the selected firms. The criteria to select the firms were the number of workers and annual sales. The mean number of employees in each industry and the mean sales value were first computed, and any firm that had simultaneously more than a half of those values was selected with the purpose of avoiding small and non-representative firms. Thus, the questionnaire was mailed to 384 companies (293 from the metal parts industry, 53 from the electronic materials industry and 38 from the paint manufacturers).

The questionnaire was developed to collect three types of information: (1) general information about the firm, including its characteristics and the industry it belongs to; (2) information that would allow an assessment of the extent to which the responding firm is using Just-in-Time; (3) information that would allow an assessment of the extent to which the respondent is familiar with the Just-in-Time system.

The design and administration of the questionnaire followed Salant and Dillman's total design method as closely as possible (Salant and Dillman, 1994). The initial questionnaire was pre-tested on operations management professors and questionnaire survey builders and, after incorporating their comments and suggestions, an intermediate version was tested on a small group of firms in order to eliminate any ambiguous and/or misleading questions. Thus, five firms were randomly chosen and the questionnaire was tested with the top manufacturing managers through personal interviews.

Comments from these managers were incorporated into the final version of the questionnaire, which consisted of 26 questions. The first six questions were about the firm's characteristics. It also contained questions about the quality system (questions 12 to 16), suppliers (questions 17 to 19), seasonality/production rate (questions 7 and 8), employee flexibility (questions 9 and 10) and preventive maintenance (questions 22 to 23); finally,

it contained one question about the production control system (question 11), the production lot size (question 20), the set-up times (question 21) and the knowledge and use or not use of Just-in-Time (question 25 and 26). Detailed information about each question is presented in the Appendix, together with the answers' codification.

In total, 142 questionnaires were received (103 from the metal parts industry, 20 from the electronic materials industry, and 14 from the paint manufacturers; 5 questionnaires did not answer questions 1 and 2). The response rate was 37%, which is better than in similar studies reported in the literature (e.g., Cheng, 1988; Bartezzaghi et al., 1992; Lee, 1992; Clarke and Mia, 1993; Lawrence and Hottenstein, 1995 and Lawrence and Lewis, 1996). However, 11 questionnaires had to be discarded because many answers were left blank, and so only 131 questionnaires could be used. Returns mirrored the composition of the original sample, indicating no systematic response bias.

The answers to eight questions (questions 9, 11, 12, 13, 16, 18, 20 and 22) had to be codified because they were categorical. Eleven of them were binomial (yes/no) and were entered into the analysis through the use of a 0-1 code. Five were continuous (the answers of questions 3, 4, 5, 6 and 17), and their values were considered. The answers to questions 1 and 2 indicate the firm's main activities and were used to distinguish the questionnaires among industries.

Main Results

Being a descriptive survey, the questionnaires were analyzed using descriptive statistics and no attempt was made to test any hypotheses. The results are based mainly on the aggregate data obtained from the 131 sets of responses.

The answers to the binomial and the dichotomic questions are presented in Figures 1 and 2. It can be seen in Figure 1 that most firms (87.5%) experience no seasonality, 74.6% of them don't need extra work, and 85.7% have flexible workers, thus having some of the necessary conditions for a Just-in-Time system. However, most firms (71.8%) still use a push method to control production (Figure 2).

Quality is a major concern; in spite of the fact that less than half of the firms have a product and/or process certification, quality is considered more important than price (Figure 2), and almost all the firms surveyed had some kind of inspection mechanism to detect defectives (Table 2). In most cases (around 85%) suppliers deliver in time and there are efforts to reduce setup times. Although used by less than one third of the firms, the Just-in-Time system is quite well known by 86.5% of them.

From the answers to question 26 it is possible to conclude that when a firm says it is using a Just-in-Time system (31.5% of them answered "yes"), that does not necessarily mean that it has consistent practices. The questionnaires with an affirmative answer to question 26 were further analysed to see if the answers to the Just-in-Time implementation conditions were consistent, and Table 2 shows the number of firms that, although

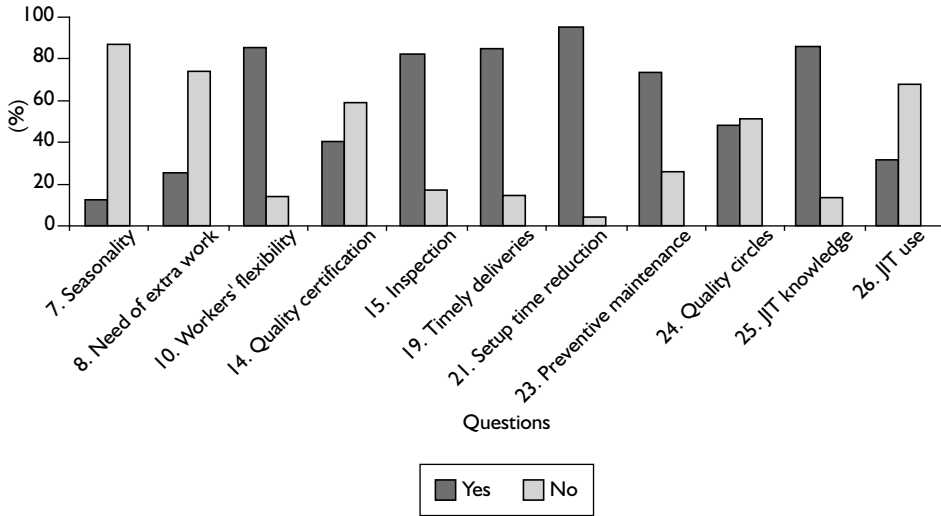


Figure 1 - Answers to yes-no questions.

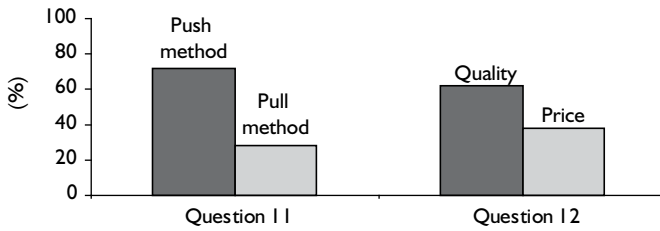


Figure 2 - Answers to dichotomous questions.

Table 2 - Answers to some questions from firms that say they use JIT.

Question	Answer	Frequency	Percentage
7	Seasonal products	5	13.8
9	Low employee flexibility	8	22.2
11	Use push control system	22	61.1
15	Any quality control system	6	16.7
20	Large lot size	12	33.3

saying they have a Just-in-Time system to control their operations, have a non-uniform production rate, are using the *push* control system, have employees with low flexibility, do not have any quality control system, or have large production lots.

Table 3 presents statistical data regarding the number of workers, sales and inventory values, and the number of suppliers of the responding companies. The number of workers ranged from 17 to 3,686, with a mean of 190. Annual sales ranged from 8,000 euros to 312,500 million euros, with a mean of 4,750 million euros. In both work-in-process and final products inventory the mean was high for companies that were trying to implement the Just-in-Time system. Even though the average number of suppliers across all firms was

high (85 suppliers for the main raw material), there was a significant proportion (40%) that had 10 or fewer suppliers.

Table 4 records data concerning the responding firms' manufacturing system profile. It can be seen that few firms (less than 25%) purchased raw materials in periods longer than

Table 3 - Statistical data of the responding firms.

Question	Mean	Mode	Std. Dev.	Min	Max
Number of employees	190	40	375	17	3,686
Sales value (10 ⁶ euros)	4,750	50,000	32,755	8,000	312,500
Final products inventory value (10 ⁶ euros)	5,745	0	37,335	0	350,000
Work-in-process inventory value (10 ⁶ euros)	4,400	500	30,640	0	275,000
Number of suppliers	85	10	321	1	3,000

Table 4 - Manufacturing system profile of the responding firms.

	Answers	Code	Frequency	Percentage
Workers' specialization	Low	1	26	20
	Medium	2	89	69
	High	3	14	11
	Total		129	100
Firm position in terms of quality	Inferior	1	0	0
	In the mean	2	59	45
	Superior	3	72	55
	Total		131	100
Where control is made	At beginning	1	10	10
	Several phases	2	81	78
	At end	3	12	12
	Total		104	100
Raw material purchases frequency	< 1 week	1	15	12
	[1,2] weeks	1.5	33	27
	]2,4] weeks	3	45	37
	[1,3] months	9	26	21
	> 3 months	30	4	3
	Total		123	100
Production lot	< 1 day	1	18	18
	[1,10] days	5	34	35
	]10,20] days	15	18	18
	]20,30] days	25	18	18
	> 40 days	40	10	11
	Total		98	100
Machine breakdown frequency	Every day	1	8	7
	[2,5] days	3	9	8
	]5,10] days	8	8	7
	]10,30] days	20	22	20
	[1,3] months	60	21	19
	]3,6] months	150	20	18
	> 6 months	270	23	21
	Total		111	100

4 weeks; of the remaining firms, roughly half purchased every 2 to 4 weeks and the other half every 2 weeks or less. In some cases the production lot was large enough to last for 20 or more days; however, more than half of the firms used lots that lasted only for 10 days or less. The time between machine breakdowns is also an important issue; some firms experienced frequent failures, but for the majority the time between machine breakdowns exceeded one month.

Question 25 asked firms about their knowledge about the Just-in-Time system. If the answer were affirmative, they were asked about its most important characteristic. Table 5 presents the most important characteristics mentioned by managers, sorted by their relative importance. It can be seen that 47 firms (about 42%) pointed out inventory reduction (in general, finished goods, and work-in-process) as the most important characteristic. For 15 firms (about 13%) good relationships with suppliers and/or timely deliveries are important issues, while 19 firms (about 17%) mentioned high quality standards and/or zero defectives as a major concern.

Table 5 - Most important characteristics of the Just-in-Time system.

JIT characteristics	Frequency
Low finished goods inventory	25
Inventory reduction	16
High quality standards	13
No delivery delays	13
Zero defects	6
Raw materials arrive as soon as needed	6
Low work-in-process inventory	6
Good relationships with suppliers	5
Suppliers deliver in time	4
Flexible production system	3
JIT production	3
Kanban	3
Continuous production flow	2
Feasible equipment	2
Production flexibility	1
Good planning	1
Set-up reduction	1
Small lot sizing	1
Good information system	1

Conclusions

Most of the surveyed firms either have only some of the conditions for a successful implementation of a Just-in-Time system or there is a significant trend towards it (like no seasonality, flexible workers, quality concern, efforts to reduce setup times, etc).

Among all the respondents only 7 firms, less than 6%, fulfill all the previously mentioned conditions.

Concerning the managers' awareness about the Just-in-Time system, the data showed that most of the sample companies were concerned primarily with its operational elements, such as reduction of inventories, quality improvement, and relationships with suppliers. So, managers do not view the Just-in-Time system as a global management philosophy nor do they recognize strategic motivations for its implementation.

It has also provided empirical data which indicate that managers are aware of the importance of quality, since almost all of the firms have an inspection system to detect defectives. However, very few of them are certified and quality circles practically do not exist. Further, most Portuguese firms do not have all the necessary conditions to successfully implement a Just-in-Time system.

This study has also shown that Portuguese firms have the following basic perspectives about the Just-in-Time system: it is perceived as a tool to reduce inventories, to increase quality and to eliminate waste, it highly depends on suppliers' performance, it helps improve quality and thus reduce scrap and defectives, and it is a tool for production planning and control.

From the analysis of the aggregate data obtained from the 131 sets of responses, the most common difficulties for the implementation of the Just-in-Time system in Portugal are: (i) most firms (more than 70%) still use a push method to control production; (ii) some firms purchase raw materials in periods longer than 4 weeks (one possible explanation is that suppliers are not considered as partners and a safety stock is kept to face poor supplier delivery performance); (iii) in both work-in-process and final products inventories the mean value was high for companies that were trying to implement Just-in-Time.

This study has some limitations. The main goal of the questionnaire survey was to find out whether Portuguese firms that have, apparently, operational conditions to adopt a Just-in-Time system, do use it. No information is available to assess what is specific about Portuguese firms, and what its impact is on the success of Just-in-Time implementation, and to compare Portuguese practices with other countries.

These limitations provide clues for future research: to find what is particular about Portugal and other recently developed countries, and what can be learned from those settings, and to establish a link between this study and the studies presented about other countries.

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References

- Aghazadeh, S. (2003), "JIT inventory and competition in the global environment: a comparative study of American and Japanese values in auto industry", *Cross Cultural Management*, Vol. 10, No. 4, pp. 29-42.
- Ahmad, A. & Mehra, S. & Pletcher, M. (2004), "The perceived impact of JIT implementation on firms financial/growth performance", *Journal of Manufacturing Technology Management*, Vol. 15, No. 2, pp. 118-130.
- Ahmed, S. & Hassan, M. & Taha, Z. (2004), "State of implementation of TPM in Small and Medium Industries: A survey study in Malaysia", *Journal of Quality in Maintenance Engineering*, Vol. 10, No. 2, pp. 93-106.
- Ahmed, N. & Tunc, E. & Montagno, R. (1991), "A comparative study of US manufacturing firms at various stages of just-in-time implementation", *International Journal of Production Research*, Vol. 29, No. 4, pp. 787-802.
- Andijani, A. and Selim, S. (1996), "The practice of production control techniques in the manufacturing sectors in the Eastern Province of Saudi Arabia", *International Journal of Production Economics*, Vol. 43, No. 2-3, pp. 251-259.
- Bartezzaghi, E. & Turco, F. & Spina, G. (1992), "The impact of the just-in-time approach on production system performance: a survey of Italian industry", *International Journal of Operations & Production Management*, Vol. 12, No. 1, pp. 5-17.
- Billesbach, T. (1991), "A study of the implementation of just-in-time in the United States", *Production and Inventory Management Journal*, Vol. 32, No. 3, pp. 1-4.
- Buxey, G. and Petzall, S. (1991), "Australian automobile industry: JIT production and labour relations", *Industrial Management and Data Systems*, Vol. 91, No. 1, pp. 8-9.
- Celley, A. & Clegg, W. & Smith, A. et al. (1986), "Implementation of JIT in the United States", *Journal of Purchasing and Materials Management*, Vol. 22, No. 4, pp. 9-15.
- Chandra, S. and Kodali, R. (1998), "Justification of just-in-time manufacturing systems for Indian industries", *Integrated Manufacturing Systems*, Vol. 9, No. 5, pp. 314-323.
- Cheng, T. (1988), "The just-in-time production: a survey of its development and perception in the Hong Kong electronics industry", *Omega*, Vol. 16, No. 1, pp. 25-32.
- Clarke, B. and Mia, L. (1993), "JIT manufacturing systems: use and application in Australia", *International Journal of Operations & Production Management*, Vol. 13, No. 7, pp. 69-82.
- Crawford, K. & Blackstone, J. & Cox, J. (1988), "A study of JIT implementation and operating problems", *International Journal of Production Research*, Vol. 26, No. 9, pp. 1561-1568.
- Cua, K. & McKone, K. & Schroeder, R. (2001), "Relationships between implementation of TQM, JIT, and TPM and manufacturing performance", *Journal of Operations Management*, Vol. 19, No. 6, pp. 675-694.

- Cusumano, M. and Takeishi, A. (1991), "Supplier relations and management: a survey of Japanese, Japanese-Transplant and U.S. auto plants", *Strategic Management Journal*, Vol. 12, No. 8, pp. 563-588.
- Daniel, S. and Reitsperger, W. (1991), "Management control systems for JIT: an empirical comparison of Japan and the US", *Journal of International Business Studies*, Vol. 22, No. 4, pp. 603-617.
- Deshpande, S. and Golhar, D. (1995), "HRM practices in unionized and non-unionized Canadian JIT manufacturing firms", *Production and Inventory Management Journal*, Vol. 36, No. 1, pp. 15-19.
- Engstrom, T. & Jonsson, D. & Medbo, L. (1996), "Production model discourse and experiences from the Swedish automotive industry", *International Journal of Operations & Production Management*, Vol. 16, No. 2, pp. 141-158.
- Forza, C. (2002), "Survey research in operations management: a process-based perspective", *International Journal of Operations & Production Management*, Vol. 22, No. 2, pp. 152-194.
- Freeland, J. (1991), "A Survey of just-in-time purchasing practices in the United States", *Production and Inventory Management Journal*, Vol. 32, No. 2, pp. 43-50.
- Gilbert, J. (1990), "The state of JIT implementation and development in the USA", *International Journal of Production Research*, Vol. 28, No. 6, pp. 1099-1109.
- Golhar, D. and Stamm, C. (1991), "The just-in-time philosophy: A literature review", *International Journal of Production Research*, Vol. 29, No. 4, pp. 657-676.
- Gonzalez-Benito, J. and Spring, M. (2000), "JIT purchasing in the Spanish auto components industry. Implementation patterns and perceived benefits", *International Journal of Operations & Production Management*, Vol. 20, No. 9-10, pp. 1038-1061.
- Gyampah, K. and Gargeya, V. (2001), "Just-in-time manufacturing in Ghana", *Industrial Management and Data Systems*, Vol. 101, No. 3, pp. 106-113.
- Handfield, R. (1993), "Distinguishing features of just-in-time systems in the make-to-order/assemble-to-order environment", *Decision Sciences*, Vol. 24, No. 3, pp. 581-602.
- Handfield, R. and Withers, B. (1993), "A comparison of logistics management in Hungary, China, Korea, and Japan", In: Whybark, D. and Vastag, G. (Eds), *Global manufacturing practices: a worldwide survey of practices in production planning and control*, Elsevier, Amsterdam, pp. 213-232.
- Hum, S. and Ng, Y. (1995), "A study on just-in-time practices in Singapore", *International Journal of Operations & Production Management*, Vol. 15, No. 6, pp. 5-24.
- Huson, M. and Nanda, D. (1995) "The impact of just-in-time manufacturing on firm performance in the US", *Journal of Operations Management*, Vol. 12, No. 3-4, pp.297-310.

- Im, J. and Lee, S. (1989), "Implementation of just-in-time systems in US manufacturing firms", *International Journal of Operations & Production Management*, Vol. 9, No. 1, pp. 5-14.
- Inman, R. and Mehra, S. (1993), "Financial justification of JIT implementation", *International Journal of Operations & Production Management*, Vol. 13, No. 4, pp. 32-39.
- Kaynak, H. and Pagán, J. (2003), "Just-in-time purchasing and technical efficiency in the US manufacturing sector", *International Journal of Production Research*, Vol. 41, No. 1, pp. 1-14.
- Kumar, V. & Garg, D. & Mehta, N. (2004), "JIT practices in Indian context: A survey" *Journal of Scientific and Industrial Research*, Vol. 63, No. 8, pp. 655-662.
- Laosirihongthong, T. and Dangayach, G. (2005), "A comparative study of implementation of manufacturing strategies in Thai and Indian automotive manufacturing companies", *Journal of Manufacturing Systems*, Vol. 24, No. 2, pp. 131-143.
- Lau, R. (2000), "A synergistic analysis of joint JIT-TQM implementation", *International Journal of Production Research*, Vol. 38, No. 9, pp. 2037-2049.
- Lawrence, J. and Hottenstein, M. (1995), "The relationship between JIT manufacturing and performance in Mexican plants affiliated with US companies", *Journal of Operations Management*, Vol. 13, No. 1, pp. 3-18.
- Lawrence, J. and Lewis, H. (1996), "Understanding the use of just-in-time purchasing in a developing country: the case of Mexico", *International Journal of Operations & Production Management*, Vol. 16, No. 6, pp. 68-90.
- Lee, C. (1992), "The adoption of Japanese manufacturing management techniques in Korean manufacturing industry", *International Journal of Operations & Production Management*, Vol. 12, No. 1, pp. 66-81.
- Matsui, Y. (2007), "An empirical analysis of just-in-time production in Japanese manufacturing companies", *International Journal of Production Economics*, Vol. 108, No. 1-2, pp. 153-164.
- Min, W. and Pheng, L. (2005), "Economic order quantity (EOQ) versus just-in-time (JIT) purchasing: an alternative analysis in the ready-mixed concrete industry", *Construction Management and Economics*, Vol. 23, No. 4, pp. 409-422.
- Monden, Y. (1998), *Toyota Production Systems: an integrated approach to just-in-time*, Engineering and Management Press, 3rd edition.
- Mould, G. and King, M. (1995), "Just-in-time implementation in the Scottish electronics industry", *Industrial Management and Data Systems*, Vol. 95, No. 9, pp. 17-22.
- Nakamura, M. & Sakakibara, S. & Schroeder, R. (1998), "Adoption of just-in-time manufacturing at US- and Japanese-owned plants: some empirical evidence", *IEEE Transactions on Engineering Management*, Vol. 45, No. 3, pp. 230-240.

- Oliver, N. & Delbridge, R. & Lowe, J. (1996), "Lean production practices: international comparisons in the auto components industry", *British Journal of Management*, Vol. 7 (Special Issue), pp. S29-S44.
- Oral, E. & Mistikoglu, G. & Erdis, E. (2003), "JIT in developing countries-a case study of the Turkish prefabrication sector" *Building and Environment*, Vol. 38, No. 6, pp. 853-860.
- Pheng, L. and Min, W. (2005), "Just-in-time management in the ready mixed concrete industries of Chongqing, China and Singapore", *Construction Management and Economics*, Vol. 23, No. 8, pp. 815-829.
- Plenert, G. (1985), "Are Japanese production methods applicable in the United States?", *Production and Inventory Management Journal*, Vol. 26, No. 2, pp. 121-129.
- Polat, G. and Arditi, D. (2005), "The JIT materials management system in developing countries ", *Construction Management and Economics*, Vol. 23, No. 7, pp. 697-712.
- Power, D. and Sohal, A. (2000), "An empirical study of human resource management strategies and practices in Australian just-in-time environments" *International Journal of Operations & Production Management*, Vol. 20, No. 8, pp. 932-958.
- Salaheldin, S. (2005), "JIT implementation in Egyptian manufacturing firms: some empirical evidence", *International Journal of Operations & Production Management*, Vol. 25, No. 4, pp. 354-370.
- Salant, P. and Dillman, D. (1994), *How to conduct your own survey*, New York, NY, John Wiley & Sons.
- Schonberger, R. (1982a), "Some observations on the advantages and implementation issues of just-in-time production systems", *Journal of Operations Management*, Vol. 3, No. 1, pp. 1-11.
- Schonberger, R. (1982b), "The transfer of Japanese manufacturing management approaches to U.S. industry", *Academy of Management Review*, Vol. 7, No. 3, pp. 479-487.
- Schonberger, R. (2007), "Japanese production management: An evolution-With mixed success", *Journal of Operations Management*, Vol. 25, No. 2, pp. 403-419.
- Sriparavastu, L. and Gupta, T. (1997), "An empirical study of just-in-time and total quality management principles implementation in manufacturing firms in the USA", *International Journal of Operations & Production Management*, Vol. 17, No. 12, pp. 1215-1232.
- Toni, A. and Nassimbeni, G. (2000), "Just-in-time purchasing: an empirical study of operational practices, supplier development and performance", *Omega*, Vol. 28, No. 6, pp. 631-651.
- Voss, C. (1984), "Japanese manufacturing management practices in the UK", *International Journal of Operations & Production Management*, Vol. 4, No. 2, pp. 31-38.
- Voss, C. and Robinson, S. (1987), "Application of just-in-time manufacturing techniques in the United Kingdom", *International Journal of Operations & Production Management*, Vol. 7, No. 4, pp. 46-52.

- Wafa, M. and Yasin, M. (1998), "A conceptual framework for effective implementation of JIT", *International Journal of Operations & Production Management*, Vol. 18, No. 11-12, pp. 1111-1124.
- Wakchaure, V.D. & Venkatesh, M.A. & Kallurkar, S.P. (2006), "Review of JIT practices in Indian manufacturing industries" 2006 IEEE International Conference on Management of Innovation and Technology 2, art. no. 4037191, pp. 1099-1103.
- Waterson, P. & Clegg, C. & Bolden, R. et al. (1999), "The use and effectiveness of modern manufacturing practices: a survey of UK industry", *International Journal of Production Research*, Vol. 37, No. 10, pp. 2271 – 2292.
- White, M. (1983), "The Japanese style of production management in Britain", *International Journal of Operations & Production Management*, Vol. 3, No. 3, pp. 14-21.
- White, R. (1993), "An empirical assessment of JIT in U.S. manufacturers", *Production and Inventory Management Journal*, Vol. 34, No. 2, pp. 38-42.
- White, R. & Pearson, J. and Wilson, J. (1999), "JIT manufacturing: a survey of implementation in small and large US manufacturers", *Management Science*, Vol. 45, No. 1, pp. 1-15.
- Wildemann, H. (1988), "Just-in-time production in West Germany", *International Journal of Production Research*, Vol. 26, No. 3, pp. 521-538.
- Womack, J. & Jones, D. & Roos, D. (1990), "The machine that changed the world: the story of lean production", Rawson Associates, New York.
- Yasin, M. & Small, M. & Wafa, M (2003), "Organizational modifications to support JIT implementation in manufacturing and service operations", *Omega*, Vol. 31, No. 3, pp. 213-226.
- Young, S. (1992), "A framework for successful adoption and performance of Japanese manufacturing practices in the United States", *Academy of Management Review*, Vol. 17, No. 4, pp. 677-700.
- Zantinga, J. (1993), "Improvements in Spanish factories: towards a JIT philosophy?", *International Journal of Operations & Production Management*, Vol. 13, No. 4, pp. 40-49.
- Zhu, Z. & Meredith, P., & Makboonprasith, S. (1994), "Defining critical elements in JIT implementation: a survey", *Industrial Management and Data Systems*, Vol. 94, No. 5, pp. 3-10.

Biography

Maria Rosário Mota Oliveira Alves Moreira graduated in Management at Universidade do Porto in 1994. In 1997 she obtained a Master in Economics at the same University. After attending some courses in Management Science, she started doing research in the field of workload and input-output control, and obtained a PhD in Business Administration in 2005 from Faculdade de Economia, Universidade do Porto, where she is presently Assistant

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Appendix: Questionnaire and Answers' Codification.

	Question	Description
1	Firm's activity	Firm's main activity
2	Other activities	Firm's other activities
3	Employees	Number of employees
4	Sales value	Sales value in thousands of euros (at the end of the year)
5	Final products inventory	Final products inventory value in thousands of euros (at the end of the year)
6	Work-in-process inventory	Work-in-process inventory value in thousands of euros (at the end of the year)
7	Seasonality	1, if the firm has seasonal products; 0, otherwise
8	Work over time	1, if the firm needs employees to work over time; 0, otherwise
9	Workers' specialization	1, if workers have low specialization; 2, if they have medium specialization; 3, if they have high specialization
10	Workers' adaptation	1, if workers can easily perform other tasks; 0, otherwise
11	Push-Pull method	1, if production control is made from the beginning to the end (push); 2, if production control is made from the end to the beginning (pull)
12	Quality vs Price	1, if quality (conformance) is more important than price in the specific firm's market; 2, if price is more important than quality (conformance) in the specific firm's market
13	Position of quality	1, if the firm has relative "less quality" than its competitors; 2, if the firm has the same quality as its competitors; 3, if the firm has relative "more quality" than its competitors
14	Quality certification	1, if the firm has a product or process certification; 0, otherwise
15	Quality control mechanism	1, if the firm has a mechanism to control the quality of the process; 0, otherwise
16	Control phase	1, if the control is made at the beginning of the production process; 2, if the control is made after more than one phase of the production process; 3, if the control is made at the end of the production process
17	Suppliers of raw materials	Number of raw materials suppliers
18	Purchases frequency (for the most important raw materials suppliers)	1, if the purchase frequency is less than 1 week; 1.5, if the purchase frequency is between 1 and 2 weeks; 3, if the purchase frequency is between 2 and 4 weeks; 9, if the purchase frequency is between 1 and 3 months; 30, if the purchase frequency is more than 3 months
19	Timely deliveries	1, if the most important suppliers deliver materials on or before the due date; 0, otherwise
20	Production lot size	1, if the production lot corresponds to less than 1 day of sales; 5, if the production lot is between 1 and 10 days of sales; 15, if the production lot is between 10 and 20 days of sales; 25, if the production lot is between 20 and 30 days of sales; 40, if the production lot is more than 30 days of sales
21	Set up reduction	1, if the firm has made efforts to reduce set-up times (by training the workers); 0, otherwise

Appendix: Continued...

	Question	Description
22	Equipment break-down frequency (average of all machines)	1, if breakdowns occur every day; 3, if breakdowns occur between 2 and 5 days; 8, if breakdowns occur between 5 and 10 days; 20, if breakdowns occur between 10 and 30 days; 60, if breakdowns occur between 1 and 3 months; 150, if breakdowns occur between 3 and 6 months; 270, if breakdowns occur in more than 6 months
23	Preventive maintenance	1, if the firm has a preventive maintenance system; 0, otherwise
24	Quality circles (teams)	1, if workers have periodic meetings with the operations/production manager to discuss subjects about the process quality; 0, otherwise
25	JIT knowledge	1, if the firm knows what JIT production system is → open answer: which are the JIT most important characteristics 0, otherwise
26	JIT use	1, if the firm has implemented the JIT system; 0, otherwise

