GESTÃO & PRODUÇÃO

ISSN 0104-530X (Print)
ISSN 1806-9649 (Online)

ORIGINAL ARTICLE

Relationship between Just in Time, Lean Manufacturing, and Performance Practices: a meta-analysis

Relação entre práticas do Just in Time, Lean Manufacturing e Desempenho: uma meta-análise

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How to cite: Lara, A. C., Menegon, E. M. P., Sehnem, S., & Kuzma, E. (2022). Relationship between Just in Time, Lean Manufacturing, and Performance Practices: a meta-analysis. *Gestão & Produção*, 29, e9021. http://doi.org/10.1590/1806-9649-2022v29e9021.

Abstract: Companies strive for superior results. Focusing on return, performance, and profitability is mainstream; this reasoning is constantly present in the decisions of the strategic operational management of companies. Based on this assumption, the objective of this work is to evaluate empirically whether the degree to which a company implements a combination of Just in Time (JIT) or Lean Manufacturing practices systematically affects the company's operational, financial, and/or organisational performance. For this, a meta-analysis was carried out; the final sample consisted of 28 articles, with 41 studies and 12,708 included subjects who provided the effects that explain the proposed relationship. The data were collected in the Web of Science, EBSCO, and Science Direct databases, with an open period, considering all works available until July 2020. Among the main findings, JIT practices and the company's operational performance present a positive, significant, medium effect. Lean manufacturing practices demonstrate a positive and significant relationship in operational, financial, and organisational performance, all with an average impact on the effect size. No direct relationship was found between the JIT variables and organisational performance (financial, operational, and environmental), based on the TBL. Additional research is needed regarding the relationship of JIT and Lean Manufacturing practices with the organisational performance (financial, operational, and environmental) based on the TBL, as well as an in-depth analysis of previous research related to green Lean practices and their relationship with organisational performance, based on the TBL.

Keywords: Just in Time Practice; Lean Manufacturing; Performance, Meta Analysis.

Resumo: Empresas zelam por resultados superiores. Focar em retorno, desempenho e lucratividade é mainstream, esse raciocínio constantemente está presente na tomada de decisão da gestão estratégica operacional das empresas. Baseado neste pressuposto, o objetivo desse trabalho é avaliar empiricamente se o grau em que uma empresa implementa uma combinação de práticas Just in Time (JIT) ou lean manufacturing afeta sistematicamente o desempenho operacional, financeiro e organizacional dessa empresa. Para isso, foi realizada uma meta-análise, a amostra final foi composta por 27 artigos, com 41 estudos e 12.708 sujeitos inclusos que forneceram os efeitos que explicam a

Received Dec. 20, 2021 - Accepted Feb. 9, 2022
Financial support: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001").

relação ora proposta. Os dados foram coletados nas bases de dados WEB of Science, EBSCO e Science Direct, com período aberto, sendo considerados todos os trabalhos disponíveis até julho de 2020. Dentre os principais achados, práticas de JIT e desempenho operacional da empresa, apresentam relação positiva e significativa, de efeito médio. As práticas de lean manufacturing demonstram relação positiva e significativa no desempenho operacional, financeiro e organizacional, todas com impacto médio sobre o tamanho do efeito. Não foi encontrada uma relação direta entre as variáveis JIT e desempenho organizacional (financeiro, operacional e ambiental), baseados no triple bottom line - TBL. Pesquisas adicionais se fazem necessárias, principalmente quanto a relação das práticas de JIT e lean manufacturing com o desempenho organizacional (financeiro, operacional e ambiental) baseados no TBL, bem como uma análise aprofundada de pesquisas anteriores relacionados as práticas enxutas verdes e sua relação com o desempenho organizacional, baseados no TBL.

Palavras-chave: Prática Just in Time; Lean manufacturing; Desempenho; Meta Análise.

1 Introduction

Although the just in time (JIT) theme is consolidated in the area of operations, investigating its nuances regarding the financial performance of companies is necessary (Yang et al., 2021). Eiji Toyoda developed an approach in which tracing the origin of a problem and correcting it leads to an improvement in the quality of products and processes (Krishna & Nair, 2018), and companies that pursue this philosophy still face challenges today. From production, JIT permeates other fields due to its plurality of applications, whether in academic environments (Zamfir, 2019) or the shipping industry (Aroca et al., 2020).

It should be noted that the literature has followed the development of this premise over the years, given the diversity of studies published on the subject. A concern reported by Mia (2000) is the difficulty in establishing a universal definition of JIT, which can generate divergences in its composition. In addition, the JIT philosophy must be implemented as a systematic and comprehensive transformation of production and operation procedures. If the ideal levels of performance are relegated to some elements of production, all the benefits of the change can be diminished, even with the generation of negative results. Otherwise, the results presented here denote duality, point to growth and long-term stability, and emphasise return on investments that may be barely observable in the short term (Fullerton et al., 2003).

Stakeholders show growing interest in the sustainability of companies, which is sometimes perceived as a conflict between fiduciary responsibility and business strategy; sustainability concerns are generally limited to environmental management or social equity (Funk, 2003). Thus, the different organisational capacities should not be limited to compensations, but should build cumulative capacities through sequential and simultaneous development and relate sustainable development to Lean production and environmental performance (Bergenwall et al., 2012). Magon, Thompe, Ferrer and Scavarda's study (Magon et al., 2018) points to the positive effects of sustainability on performance, although different mechanisms drive performance-sustainability links according to their contexts.

There is still a concern among professionals and researchers to test lean production practices and provide success in companies. Therefore, research on the relationship between lean practices and business performance (operational, financial, market performance, etc.) has gained prominence between the scientific and business world at world level.

However, there is a paucity of in-depth studies on the non-linear relationship between lean practices and business performance, and Meta Analysis studies are alternative investigations in this field Liu et al. (2020).

In order to respond to this theoretical gap, the following research question was formulated: to what extent does the degree to which a company implements a combination of JIT or lean

manufacturing practices systematically affect the operational, financial, and organisational performance of that company? In order to meet this concern, the objective is to assess empirically the degree to which a company's implementation of a combination of JIT or lean manufacturing practices systematically affects their operational, financial, and organisational performance. A meta-analysis was carried out with 28 articles comprising 41 different studies, which provide estimates regarding the effects generated by the relationship between JIT and performance. The metric defined to analyse the effect size, in this meta-analysis, was the correlation coefficient. Studies that presented other measures, such as the T student, were converted into a correlation coefficient in order to follow the precepts of the meta-analysis (Lipsey & Wilson, 2001). Heterogeneity tests and a meta-analytical path model were performed to assess the underlying mechanisms of the effects of JIT practices on financial performance.

The use of meta-analysis is justified by the opportunity to draw a panorama about the state of the art of the subject on screen, in view of the amount of results obtained, sometimes different, when not contradictory (Brei et al., 2014). In addition to that meta-analysis allows to estimate the pattern of effects, so that if the effect size is consistent across studies, one can focus on the mean. On the other hand, if there is variation in effect size between studies, one can discuss the extent of this variation and explain them from the perspective of the intervention's usefulness (Borenstein, 2019). With the advent of technology, innovations tend to enter to potentialize the use of JIT. The study by Pascarella et al. (2019) points out that it is possible to predict with up to 82% of defective files, which would allow to minimise inspection expenses, in the face of the standard just in time technique. The research by Seidgar et al. (2015) used the JIT concepts, such as machine preemption, machine downtime, and unequal release times, in proposing a new mathematical model that validates the percentage deviation related to computational time. They also clarify better performance than other algorithms in solution quality and computational time. For business practice, there is the question of the cost versus benefits in implementing such solutions.

After this introductory section, the literature review is presented, with the requirements of JIT and lean manufacturing practices and their relevance to the performance of companies. The research method is detailed in section 3. Next, the results are presented and analysed. In the last section, the conclusions, limitations of the study and suggestions for future research are discussed.

2 Theoretical framework

2.1 JIT Practices and performance

When approaching the just in time (JIT) system, according to the premises developed by Taiichi Ohno, two main resources must be highlighted: first, only the necessary products, in the necessary time, in the necessary quantity are manufactured, with the stock reduced to the minimum. Secondly, the system is based on respect for the human being, in which workers can fully display their capabilities through active participation in the execution and improvement of their own activities (Sugimori et al., 1977). However, the Toyota Production System (STP), with JIT and Kanban as its pillars, has limited understanding as to its true scope and potential (Ghinato, 1995). From JIT exchanges (Frazier et al., 1988), to software systems with JIT compilation techniques (Aycock, 2003), a broad spectrum of teaching and learning environments is available to interested companies (Novak et al., 1999).

It is necessary to measure such results of JIT practices through performance indicators, whether financial or non-financial (Upton, 1998), since just in time, total quality management, and supply chain management are seen by organisations as part of their operations strategy (Kannan & Tan, 2005). Further, these practices are considered improvement initiatives that organisations seek to achieve their organisational objectives, improve competitiveness, and increase market share (Iqbal et al., 2018). JIT practices are seen as a positive strategy, especially in the Japanese manufacturing sector and in other developed countries such as the United States, the United Kingdom, and Australia. The implementation of such practices in developing countries is incipient (Karim, 2019). Thus, several studies investigate the effects of implementing JIT on operational performance, financial performance, and on company growth. Studies that rely solely on short-term financial performance indicators to justify the benefits of implementing JIT are misleading and can harm the survival of a business' long-term future (Ahmad et al., 2004).

A meta-analytical study regarding the relationship between just in time manufacturing practices and performance, developed by Mackelprang & Nair (2009), indicates that each individual JIT practice is positively correlated with aggregate performance. Although the practice may not be positively associated with performance measures, JIT practices, when considered individually, can interact with each other. This results in varying degrees of performance improvement. It indicates that the associations of small lots, preventive maintenance, and pulled systems with aggregate performance are influenced by moderating factors, and future studies are appropriate here. The research by Sakakibara et al. (1997) indicated that there was no significant relationship between the use of JIT practices, alone, and the performance of manufacturing. There was a strong relationship between JIT practices and infrastructure practices; the combination of JIT management and infrastructure practice was related to manufacturing performance. The infrastructure alone is sufficient to explain manufacturing performance, and manufacturing performance was related to competitive advantage. More recently, studies are directing efforts to understand the impact of JIT on environmental performance, by pointing out results where additional environmental performance is in conflict with economic performance (Kong et al., 2018); green supply chain practices, total quality control, and JIT positively influence both operational and business performance (Agyabeng-Mensah et al., 2021).

Thus, hypotheses 1 (H1a, H1b) are elaborated as follows:

H1a: JIT practices positively affect operational performance.

H1b: JIT practices positively affect financial performance.

2.2 Lean and performance practices

The premises of the Lean methodology include those related to the optimization of warehouse resources, such as stock, material handling equipment, loading / unloading operations, personnel and ensuring that innovative solutions are available, that is, the elimination of waste can be relevant, since warehouse operations must be able to adopt waste elimination in their operations (Abushaikha et al., 2018). The term "lean storage" is relatively new in the literature (Sharma & Lean practices include bottlenec, 2016), but several studies have investigated the effect of lean production on performance (Shah & Ward, 2003; Fullerton & Wempe, 2009; Ghosh, 2013; Bellisario & Pavlov, 2018).

Lean practices include bottleneck removal Lean production (production smoothing, cellular manufacturing, competitive benchmarking, continuous improvement programs,

multifunctional workforce, cycle time reductions, focused factory production, JIT/continuous flow production, lot size reductions, maintenance optimisation, new equipment/process technologies, planning and scheduling strategies, preventive maintenance, process capacity measures, pull/kanban system, quality management programs, fast change techniques, process of redesigned production, safety improvement programs, self-directed work teams, and total quality management) (Shah & Ward, 2003). It should be noted that just using the tools or promoting some changes in stages of the manufacturing processes will not be enough. Instead, it is necessary to draw a new perspective regarding the conduct of business, the management of directors, how managers manage, and how workers perform their daily work (Melton, 2005).

However, studies raise different considerations, since there is no strong link between inventory management practices and financial performance indicators, although companies have applied these practices in a remarkable way (Folinas & Fotiadis, 2016). Inventory/sales ratio negatively affects the organisation's performance in the initial phase of growth and maturity and has a positive and significant effect on performance both in the rapid growth stage, and in the rebirth stage (Elsayed & Wahba, 2016). Companies still have the potential to increase their ability to become leaner by empirically investigating the stock-performance link (Isaksson & Seifert, 2014). The debate on the relationship between lean practices and business performance needs to be deepened, as well as simultaneously testing operational, financial, and environmental performance as a result of adopting lean manufacturing practices (Negrão et al., 2019).

In this sense, hypotheses 2 (H2a, H2b) were elaborated as follows:

H2a: Lean manufacturing practices positively affect operational performance.

H2b: Lean manufacturing practices positively affect financial performance.

2.3 Lean manufacturing practices and business sustainability

Growing awareness of sustainability and the Triple Bottom Line (TBL) approach points out that the success of a corporation can and should be measured not only by traditional financial results. Instead, an organisation’s integral performance should be based on three main objectives: economic growth, environmental preservation, and social responsibility (Norman & MacDonald, 2004). The term “sustainability” mainly addresses the relationship between business and the TBL agenda; it evaluates companies not only on the economic value they add, but also on the environmental and social value they add - or destroy (Elkington, 1997). An understanding of the interrelationships among the different components of sustainability, governance, manufacturing and finance, needs a perception of integrated development, so the effects of measures as a whole, whether positive or negative, are more than the simple sum of effects of their distinct measures, due to the synergistic effects of their actions (Zamagni, 2012).

Despite this, there is a limitation on the part of organisations in understanding the factors that influence lean sustainability in all environments of the organisation (Lopes, 2019). Given the relevance that Lean manufacturing has acquired, it is important to understand its effects on sustainability. Knowledge gaps on the subject remain and require further research. The effect on performance from a multidimensional point of view represents all three pillars (Henao et al., 2019).

Studies show that environmental management directly improves environmental and social performance, but contributes only indirectly to economic results (Giovanni, 2012). A bibliometric study by Almeida & Picchi (2018) indicates that the theme has gained

importance in the last five years, with the United States and Brazil as major contributors. The relationship between the approaches is synergistic between lean construction for sustainability and the strengthened relationship from the alignment of concepts of value and waste. Even so, there are few studies available that deepen the theme. Furthermore, JIT and TQM are directly and positively associated with green supply chain management practices, being complementary, thus providing a greater impact on environmental performance than if implemented individually (Green et al., 2019). That said, hypothesis 3 was elaborated as follows:

H3: lean manufacturing practices positively affect organisational performance (financial, operational, and environmental), that is, the environmental and economic dimensions of TBL.

Figure 1 illustrates the proposed theoretical model and its respective hypotheses:

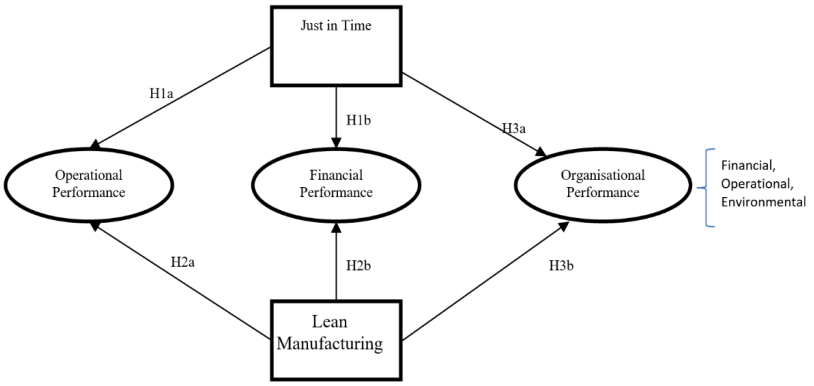

Figure 1. Theoretical model and research hypotheses.

3 Methodological procedures

First, an article was used as the basis that provided the measurement scale proposed: An examination of the relationships between JIT and financial performance (Fullerton et al., 2003). This title was used as a search term, after returning the manuscript to the searched databases, it was possible to identify all the studies that cited this study. Subsequently, the protocol to carrying out the meta-analysis followed was that prescribed by Cooper (2010). From this, the research problem was formulated. The variables were categorised as: independent variable: JIT (taking into account the following practices: JIT, lean production, Lean manufacturing, inventory efficiency, operations performance, inventory performance, lean practice packages, waste reduction), and dependent variables: performance (considering operational performance, financial performance, organisational performance, business performance, business performance), according to the precepts of Fullerton et al. (2003).

Then, a search for the title of the article was carried out in the databases Web of Science, Scopus, and Science Direct, given the relevance and scope for the area of applied social sciences. The results referring to the citations has totaled 440 articles. All works available until July 2020 were considered. The types of documents selected were articles and articles in press, covering all areas. The search was performed in August 2020. Table 1 shows the number of articles, according to the search base.

Table 1. Articles available by database.

Databases	*n	%
Scopus	264	60
Web of Science	3	1
Science Direct	173	39
Total	440	

n: number of articles mapped

After identifying the potential studies for the meta-analysis, inclusion and exclusion criteria were applied, and initially duplicated works and those with qualitative methods were disregarded. After the extraction of those articles, the studies were sorted and the bibliographic portfolio to be analysed was secured in this research. The titles, abstracts, and keywords were read, then the other criteria for sample selection were applied following the recommendations of Borenstein et al. (2009): 1) Complete works, which adhered to the objective of present study and relationship between JIT and performance, 2) works written in the English language, 3) inclusion only of articles that provided sufficient statistical data to code or calculate the effect size, with correlation coefficients between the variables or data required to obtain them using conversion methods.

Finally, after screening the articles, the final database was made up of 28 articles, with 41 different measurements, and with 12,708 subjects included, who provided the effects that explain the relationship now proposed. Excluded from this analysis was a study by Capkun et al. (2009), regarding the relationship between stock performance and financial performance in manufacturing companies based in the United States, as it is a longitudinal study carried out between 1980 and 2005; with 52,254 observations per year, it is configured as outliers compared to other studies. The article finds a significant positive correlation between stock performance and financial performance measures, which results in value creation for manufacturing companies. Figure 2 illustrates the complete article selection and screening process.

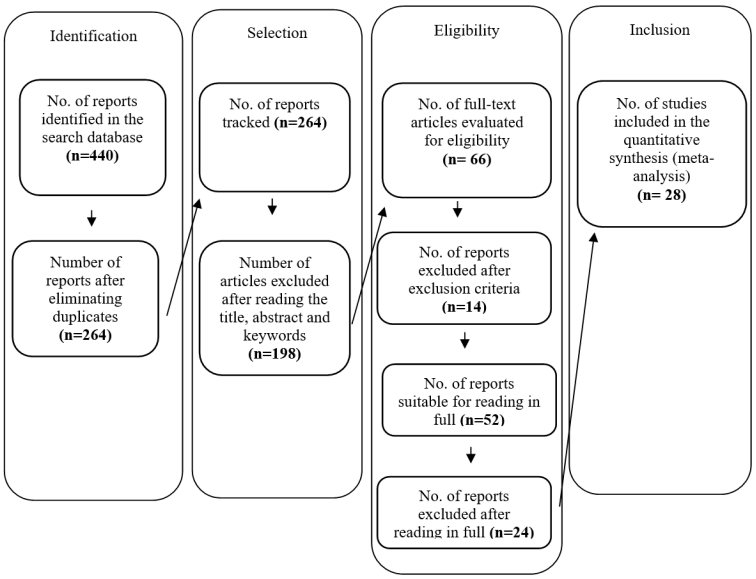

Figure 2. Complete Article Selection and Screening Process. n: number of articles mapped

To obtain the p-value for each of the hypotheses, the meta-analysis process seeks to homogenize the values of each study for the composition of the final study sample. In this format, the different values of the statistical tests of each study are transformed through a common correlation, which allows the inclusion and transformation of studies with different statistical models, as prescribed by Cooper (2010). There is no incongruity in the data as the raw results are transformed to compatible correlation for meta-analysis.

It was necessary to verify the heterogeneity of the studies listed due to the diversity of variables and ways of measuring the data used; this step minimised the impact of the variability of previously published measurements (Brei et al., 2014) and it considered that if there is variation in the effect size between studies, there is a possibility to discuss this variation (Borenstein, 2019). For this purpose, the Higgins I2 is used, which measures in percentage terms the degree of heterogeneity, according to Field & Gillett (2010), with 96.78%. The metric analyses effect size, which, in this meta-analysis, was the correlation coefficient due to its easy interpretation. In other words, a positive correlation coefficient indicates that the greater the degree of implementation of JIT practices, the better the financial performance of companies. Studies that presented other measures, such as the T student, were converted into a correlation coefficient, in order to follow the precepts of the meta-analysis (Lipsey & Wilson, 2001; Brei et al., 2014).

Table 2 shows the steps followed in this study. In addition, we adopt the meta-analysis protocol followed by Kuzma et al. (2020). See the number of studies included in the quantitative synthesis (meta-analysis).

Table 2. Steps of the meta-analysis.

Phases	Performed activities
Problem formulation	Conceptualize the problem; Establish inclusion criteria for admissible studies; Define variables; Develop protocol and coding spreadsheets.
Literature revision	Collection of scientific studies already published.
Data evaluation	Check abstract data; Check the quality of the research (adherence to the objective of the study); Classify and categorise the characteristics of the study; Identify independent comparisons.
Data analysis	Calculate the main effects and interactions; Measure the strength of the relationship; Assess the magnitude of the effect size between studies in a summary measure.
Interpretation and presentation	Analyse the implications of the effect size; Summarise methods and findings; Disseminate research findings

Source: Adapted from Brei et al. (2014) and Lipsey & Wilson (2001).

4 Presentation and analysis of results

According to the application of the sample selection criteria and the research protocol, a total of 28 articles were obtained. The studies focus on investigating theoretical gaps, testing hypotheses of relationships between the use of JIT and Lean manufacturing practices with the performance of companies (operational, financial, and organisational). The period of the publications listed is from 2004 to 2020, with a homogeneous distribution between the years. The results of the descriptive categorisation of the meta-analysis are shown in Table 3:

Table 3. Result of the Descriptive Categorisation of the Meta-Analysis.

*N	Authors / Year	Type of Economy	Economic Sector	Method	Google Citations
1	Abushaikha et al. (2018)	B	1	1	19
2	Ahmad et al. (2004)	A	2	1	123
3	Bashar & Hasin (2019)	C	2	1	1
4	Burawat (2018)	B	2	1	-
5	Callen et al. (2010)	A	2	1	74
6	Cannon (2008)	A	2	2	146
7	Chen & Tan (2013)	A	2	2	63
8	Chen & Tan (2011)	A	2	1	41
9	Elsayed & Wahba (2016)	B	2	2	35
10	Eroglu & Hofer (2011)	A	2	2	380
11	Folinas & Fotiadis (2016)	B	2	1	-
12	Folinas et al. (2017)	B	2	1	11
13	Fullerton & Wempe (2009)	A	2	2	547
14	Hofer et al. (2012)	A	2	3	316
15	Hong et al. (2014)	B	2	1	3
16	Iqbal et al. (2018)	B	2	1	34
17	Isaksson & Seifert (2014)	A	2	2	58
18	Kinney & Wempe (2004)	B	2	2	16
19	Losonci & Demeter (2013)	B	2	2	69
20	Maiga & Jacobs (2009)	A	2	1	31
21	Manikas (2017)	A	2	2	1
22	Nawanir et al. (2016)	B	2	1	28
23	Nawanir et al. (2013)	B	2	2	144
24	Negrão et al. (2019)	B	2	1	2
25	Panwar et al. (2017)	B	2	1	24
26	Rasit et al. (2018)	B	2	1	3
27	Yu et al. (2021)	A	2	1	-
28	Zhu & Lin (2018)	A	2	2	4

Note: Type of economy: A = developed economy; B = in development; C = underdeveloped, according to criteria of the International Monetary Fund (IMF, 2020); n: Number of articles mapped.

Economic Sector 1- Service; 2- Product

Method: 1- Survey; 2- Secondary Data; 3- Mixed

The surveyed companies are based in developing and developed economies; only one study was conducted in the underdeveloped economy of Bangladesh (Bashar & Hasin, 2019). The data collection method of the analysed articles is through a survey and secondary data, mainly from the Compustat database. Only 1 study has a mixed collection (primary and secondary data) in the proportion of 49.25% for Survey, and 37.03% for secondary data from a database. The form of data collection follows in a homogeneous way, since all data were collected via online instruments, which facilitates the researcher's access to a larger sample of research.

Regarding the journals that publish on the subject, 22 different journals are represented. Table 4 shows the sample distribution by periodical with more than one publication:

Table 4. Distribution of the sample by journal.

Order	Journals	n	Impact Factor
1	International Journal of Production Economics	3	5,134
2	Contemporary Accounting Research	2	2,026
3	Int. J. Logistics Systems and Management	2	-
4	International Journal of Productivity and Performance Management	2	-
5	Journal of Engineering and Applied	2	-
6	Journal of Manufacturing Technology Management	2	3,385
7	Production Planning & Control	2	3,605
X	13 journals with 1 publication	13	-
	Total articles	28	

n: number of journals.

Among the most relevant journals, the International Journal of Production Economics stands out, with an impact factor of 5.134. Its focus is related to the manufacturing and process industries, production in general, and its objective is to improve industrial practice and strengthen the base theoretical framework needed to support sound decision-making. Production Planning & Control, with an impact factor of 3,605, focuses on managing operations in all industries in order to guide the activities of managers and future researchers. The Journal of Manufacturing Technology Management, with an impact factor of 3,385, aims to publish studies aimed at managing manufacturing technology and integrating the design, production, marketing and supply functions of companies. This focus reveals that the subject is debated and published by renowned means of disseminating scientific knowledge. The Table 5 presents a meta-analysis for the relationship between JIT and lean manufacturing with financial and operational performance the combination of the effects.

Table 5. Meta-analysis for the relationship between JIT and lean manufacturing with Financial and Operational Performance the combination of the effects.

N.	Authors of the Studies	N	R	Effect Size	CI Lower limit	CI Upper limit	Weight	Hypothesis
1	Zhu & Lin (2018)	1559	1.620	0.04	-0.01	0.09	2,62%	H2b
2	Zhu & Lin (2018)	1559	1.650	0.04	-0.01	0.09	2,62%	H2a
3	Nawanir et al. (2013)	139	0.610	0.65	0.54	0.74	2,46%	H2b
4	Nawanir et al. (2013)	139	0.700	0.74	0.65	0.80	2,46%	H2a
5	Fullerton & Wempe (2009)	244	5.783	0.35	0.23	0.45	2,53%	H2b
6	Elsayed & Wahba (2016)	84	0.032	0.08	-0.14	0.29	2,35%	H3
7	Elsayed & Wahba (2016)	84	0.194	0.24	0.02	0.43	2,35%	H3
8	Yu et al. (2021)	241	0.482	0.52	0.42	0.61	2,53%	H2b
9	Cannon (2008)	272	0.022	0.07	-0.05	0.19	2,55%	H2b
10	Cannon (2008)	272	0.036	0.09	-0.03	0.20	2,55%	H2b
11	Isaksson & Seifert (2014)	353	0.021	0.07	-0.03	0.17	2,57%	H2b
12	Folinas & Fotiadis (2016)	12	3.150	0.87	0.54	0.97	1,26%	H2b

Table 5. Continued...

N.	Authors of the Studies	N	R	Effect Size	CI Lower limit	CI Upper limit	Weight	Hypothesis
13	Negrão et al. (2019)	1387	0.554	0.59	0.56	0.63	2,62%	H3
14	Nawanir et al. (2016)	236	3.820	0.24	0.12	0.36	2,53%	H2b
15	Losonci & Demeter (2013)	453	1.100	0.05	-0.04	0.14	2,58%	H2b
16	Eroglu & Hofer (2011)	54	0.750	0.79	0.65	0.87	2,21%	H2b
17	Hong et al. (2014)	571	0.358	0.42	0.35	0.48	2,59%	H2b
18	Burawat (2018)	229	0.206	0.61	0.52	0.69	2,53%	H2a
19	Iqbal et al. (2018)	248	0.064	0.25	0.13	0.37	2,54%	H1b
20	Iqbal et al. (2018)	248	0.242	0.11	-0.01	0.23	2,54%	H1a
21	Iqbal et al. (2018)	248	0.270	0.02	-0.11	0.14	2,54%	H1b
22	Iqbal et al. (2018)	248	2.931	0.02	-0.11	0.14	2,54%	H1a
23	Abushaikha et al. (2018)	90	0.419	0.30	0.09	0.48	2,37%	H2b
24	Burawat (2018)	229	1.555	0.46	0.35	0.56	2,53%	H2b
25	Panwar et al. (2017)	121	0.238	0.14	-0.04	0.31	2,44%	H2a
26	Fullerton & Wempe (2009)	244	0.536	0.28	0.16	0.40	2,53%	H2b
27	Manikas (2017)	1286	0.240	0.58	0.54	0.61	2,62%	H2b
28	Hofer et al. (2012)	229	0.374	0.29	0.16	0.40	2,53%	H2b
29	Rasit et al. (2018)	200	0.405	0.42	0.29	0.53	2,51%	H1b
30	Bashar & Hasin (2019)	227	1.709	0.45	0.34	0.55	2,53%	H1b
31	Maiga & Jacobs (2009)	131	0.426	0.15	-0.02	0.31	2,45%	H1b
32	Callen et al. (2010)	39	5.590	0.47	0.17	0.69	2,07%	H1a
33	Callen et al. (2010)	39	0.105	0.68	0.45	0.82	2,07%	H1a
34	Callen et al. (2010)	61	0.250	0.15	-0.11	0.39	2,26%	H1b
35	Ahmad et al. (2004)	86	0.011	0.29	0.09	0.48	2,36%	H1b
36	Kinney & Wempe (2004)	148	0.880	0.06	-0.10	0.22	2,47%	H1b
37	Folinas et al. (2017)	125	4.642	0.95	0.93	0.97	2,44%	H1b
38	Chen & Tan (2011)	224	2.050	0.30	0.17	0.41	2,53%	H1a
39	Chen & Tan (2013)	173	0.874	0.15	0.00	0.30	2,49%	H1a
40	Ahmad et al. (2004)	86	1.620	0.02	-0.19	0.24	2,36%	H2b
41	Abushaikha et al. (2018)	90	1.650	0.09	-0.12	0.30	2,37%	H2a

Note: N - citation number; R- correlation coefficient; CI - correlation limit

Below, Table 6 presents the combination of effects and heterogeneity found in the meta-analysis study

Table 6. Combination of effects.

Combination of combined effects		Heterogeneity	
Correlation	0.353	Q	1242.80
Confidence interval LL	0.244	p_Q	0.000
Confidence interval UL	0.453	I^2	96.78%
Prediction interval LL	-0.280	T^2 (z)	0.10
Prediction interval UL	0.772	T (z)	0.32
Z-value	6.22		
One-tailed p-value	0.000		
Two-tailed p-value	0.000		

The Cochran Q test is the method used to assess the heterogeneity of the study, and if the findings of the primary studies are the same and the null hypothesis is confirmed, the studies are considered homogeneous (p> 0.05). In this study, the p-value is 0.000, which indicates that there is some (indeterminate) degree of heterogeneity. The I2 statistic can range from negative values up to 100%. When the value is close to 0% it indicates non-heterogeneity between studies, close to 25% indicates low heterogeneity, close to 50% indicates moderate heterogeneity, and close to 75% indicates high heterogeneity between studies (Santos & Cunha, 2013). The value recorded for I2 is 96.78%, which indicates that the studies that compose this meta-analysis are not studies from the same population. T2 (z) and T (z) calculate the dispersion of the true effect sizes between studies, in terms of the effect size scale. The value of Rosenthal fail-safe indicates the number of studies needed to refute significant meta-analytical means (Fragkos et al., 2014), in this study is 16,939, which indicates that the number of unpublished documents needed to make the insignificant observed effect size is large, and any publication bias is unlikely. The combined effects are shown in Figure 3:

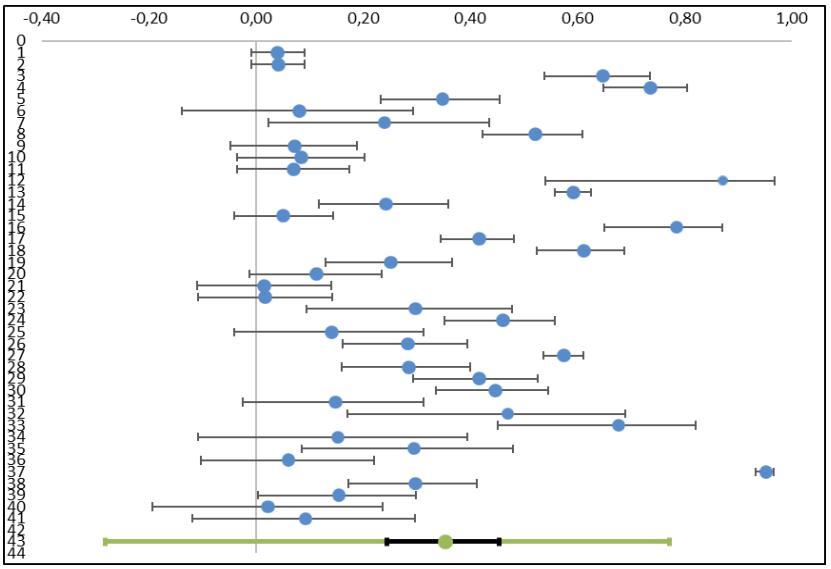

Figure 3. Forest Plot about Combined effects. Note: Research data (2020).

The graph illustrates the relative strength of the treatment effects found in the studies listed in this meta-analysis. It presents the amount of variability of the effects, with heterogeneous and strongly positive results. Visual analysis allows inferring, from the effect-size and confidence intervals, the positive relationship between the variables presented in the studies of the analysed sample. This facilitates the visual comparison of the findings of different studies.

From the tested Hypotheses, formed based on the constructs on JIT and Lean manufacture, they were related to operational performance, financial performance and organisational performance. The impact that the relationship presents may be of small effect $\bar{r}$ = 0.10; medium effect $\bar{r}$ = 0.30, and large effect $\bar{r}$ = 0.50 (Abrami et. al, 1988). The meta-analysis results are shown in Table 7:

Table 7. Summary of results.

Hypotheses	r	p-value	Supported
H1a: JIT → Operational Performance	0.454	0.000	Yes
H1b: JIT → Financial Performance	0.232	0.083	No
H2a:Lean Manufacturing → Operational Performance	0.411	0.004	Yes
H2b: Lean Manufacturing → Financial Performance	0.348	0.000	Yes
H3: Lean Manufacturing → Organisational Performance (financial, operational, and environmental)	0.333	0.028	Yes

r: correlation coefficient; p: significance value (p=0.05).

As for the results, Hypothesis H1a, which tests the relationship between the degree of use of JIT practices and their impact on the company's operational performance, was supported, considering the combined effect size coefficient as averag.e at r = 0.454 (p- value <0.000). The cumulative results of 6 studies showed a significant correlation between the two variables. Although previous studies by Iqbal et al. (2018) point out that total quality and JIT do not directly contribute to operational performance, there is a significant relationship when agile manufacturing initiatives are implemented concurrently, and the market performance positively mediates the relationship between operational performance and financial performance. Companies that use JIT practices are more efficient and profitable than those that do not, that is, industry-oriented productivity measures are more profitable and efficient than idiosyncratic productivity measures (Callen et al., 2010).

Hypothesis H1b, which tests the relationship between the degree of use of JIT practices and its impact on the company's financial performance, was not supported. There was a small impact on the size of the combined effect at r = 0.232 (p-value <0.083). Nine studies were tested that showed that there was no significant relationship between the two variables analysed. The study by Folinas et al. (2017), corroborate these findings, indicating that there is no strong link between JIT practices and the financial performance of organisations. Still, previous studies that analysed the relationship between JIT and financial performance point out other forms of correlation, such as companies that implement the JIT system with more advanced performance measurement systems (for instance, financial and non-financial measures) (Rasit et al., 2018), the mediating role of JIT (Qamruzzaman & Karim, 2020), or that there are gaps between the actual levels of JIT implementation and the expected level (Salehi et al., 2010).

Regarding Hypothesis H2a, which tests the relationship between the degree of use of Lean manufacturing practices, impacts on the company's operational performance, was supported demonstrating an average impact, with a combined effect size of r = 0.411 (p- value < 0.000). The results of 5 studies showed a significant correlation between the two

variables. This result corroborates the findings of Liu et al. (2020) who demonstrate in their meta-analysis research that there is a significant positive correlation between lean practices and operational performance, the results are consistent with the results of conventional research, which validate the positive results between lean practices and operational performance, recommending organizations that invest manpower, time and resources to carry out lean practices.

However, other studies complement that Lean manufacturing practices can only improve the performance of operations in the short term due to their inability to maintain such practices over time (Zhu & Lin, 2018). In the meantime, lean practices must be implemented holistically, with greater effort in order to improve the level of implementation (Nawanir et al., 2013).

On hypothesis H2b, which tests the relationship between the degree of use of Lean Manufacturing practices and the impact on the company's financial performance, was supported. The relationship was considered average, with the combined effect size at r = 0.348 (p-value <0.004), with a strong impact effect, due to the number of studies on the subject, and the influence expressed in the financial performance of companies. The combined results of 18 studies showed a significant correlation between the two variables. A study by Nawanir et al. (2016) corroborates the research findings and points out that the simultaneous implementation of all Lean Manufacturing practices meets the complementarity theory. This means that the superior and competitive performance is likely through the advantage of complementarity of organisational practices, such as Lean Manufacturing, in order to maintain competitive advantage for a long period of time. However, there is potential to increase the capacity of companies to become leaner (Isaksson & Seifert, 2014).

Hypothesis H3, which tests the relationship between the degree of use of Lean manufacturing practices, impacts the company's organisational performance (financial, operational, and environmental), was supported. It considers the combined effect size coefficient as average at r = 0.333 (p-value <0.028). The accumulated results of 3 studies showed a significant correlation between the two variables; however, despite the low number of publications, the effect of medium impact indicates the relevance of further investigations on the topic. Previous studies have analysed the relationship between Lean Manufacturing and organisational performance (financial, operational, and environmental) among Lean Manufacturing practices with a significant impact on supply chain sustainability; these studies cite waste disposal, supply chain risk management, and cleaner production. The practices of flexible transport, flexible supply, ISO 14001 Certification, and reverse logistics do not have a significant impact on the company's sustainability (Govindan et al., 2014). The effect of Lean manufacturing on performance, considering the three pillars of the triple base, needs more research. Knowledge gaps remain on the subject: one strand supports complementary interactions between Lean Manufacturing and the three pillars of the triple bottom line, while another perspective reserves trade-offs between them (Henao et al., 2019).

The incorporation of practices aligned with the JIT provides advantages for companies. Potential gains include cost reduction and optimisation of the production process, with improved organisational performance. The reduction in inventories is also an effect of its application, as well as the possibility of improving product quality, reducing delivery times due to the agility of all stages of production. This implies gains in the satisfaction of business partners, buyers, and customers, and it may create a competitive advantage for the company (Barud et al., 2020). Through meta-analysis, the effects of previous studies on the theme were combined to obtain a broader result on the studied relationship.

In the context of operations, the principles of minimising waste and inventories imply the synchronization of operational processes to ensure the punctuality of operations. Demand i)

production planning, with lean operations, production planning and material systems based on demand and flexibility of operational processes, ii) strategic support for tactical operations to promote the achievement of objectives and goals, as well as the analysis of costs of material and inventories, and iii) logistics facilitated by the optimisation and integration of the resources spent to enable the disaggregated storage and transport actions (Cai et al., 2021).

5 Final remarks

This article aims to empirically assess whether the degree to which a company implements a combination of JIT or Lean Manufacturing practices systematically affects the operational, financial, or organisational performance of that company. The objective was met by conducting a meta-analysis that tests hypotheses of these relationships. The main results of the meta-analysis contribute to the existing literature as follows: a positive and significant relationship, of medium effect, was demonstrated between the adoption of JIT practices and the company's operational performance. As for Lean manufacturing practices, there is a positive and significant relationship in operational, financial, and organisational performance, all with an average impact on the size of the effect. The hypothesis that JIT practices have an impact on companies' financial performance was not supported; however, when analysing other variables concomitantly, the practices do demonstrate a positive result. Among the studies listed in the meta-analysis, no direct relationship was found between the JIT variables and organisational performance (financial, operational, and environmental); however, studies point to a combination of efforts when analysing JIT practices with TQM, green processes, and and its relationship with organisational performance backed by TBL directives.

Organisations are faced with environmental and social issues, and JIT practices can be encouraged to enable sustainable success in its various dimensions. The results of the meta-analysis make it possible to ensure that JIT practices positively influence companies' operational performance, as well as Lean manufacturing practices positively influence companies' operational, financial, and organisational performance. The study provides evidence that organisations can benefit from achieving better sustainability performance from Lean manufacturing practices. As a main contribution, it presents a result of combined effect regarding a considerable evaluation of empirical studies referring to the theme; further, it allows the supply of useful inferences for future studies dedicated to investigating the relationship between JIT or Lean Manufacturing and operational performance, financial, and organisational, the latter based on the TBL. This study provides a managerial contribution by inferring that the adoption of Lean manufacturing practices influences the performance of companies, whether in the operational, financial, and organisational dimensions, as well as JIT practices, especially if combined with other variables, point to a better operational performance.

6 Limitations and recommendations

Although the objective of the study was achieved, limitations were observed. Among them, the measurement scales of the constructs related to JIT and Lean Manufacturing, surveyed in the sample, addressed different theoretical currents, which can differ the format and structure of the measurements and influence the results obtained. Another limitation refers to the initial scope of the study, focused on addressing previous studies regarding the relationship between JIT and financial performance, according to the measurement scale

proposed by Fullerton et al. (2003). The studies defined in the sample encompassed other dimensions that allowed expanding the analysis for the relationship with operational and organisational performance, in addition to realising that Lean manufacturing practices are also the target of research that deserve the attention of the academy.

Additional research is needed, especially regarding the relationship of JIT and Lean Manufacturing practices with the organisational performance (financial, operational, and environmental) based on the TBL. Nevertheless, future studies should incorporate other elements of Lean manufacturing as moderating variables in order to test the impact of each element in the relationships currently evaluated. Comparisons can be made between the effects, either individually or concurrently, in order to test the relationships synergistically. Finally, the study can be strengthened with an in-depth analysis of previous research related to green lean practices and their relationship with organisational performance, based on the TBL.

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