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Sustainable industries: Production planning and control as an ally to implement strategy

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ABSTRACT

Although there are many studies on strategy formulation, little research has been done on how to improve strategy implementation in industries. The focus of this study is to analyze the variables that can make Production Planning and Control (PPC) an important ally in the strategy implementation process to assist sustainable industries to be more competitive. The methodology used was multiple case study supported on interviews with production planning and control managers of six renowned Brazilian industries, considered sustainable by their concern with the social and environmental cause, beyond the economic. Using Multiple Correspondence Analysis (MCA), it was possible to separate these industries in three different groups by the number of employees for analysis, where PPC had a different role, and so identify the following variables that can differentiate PPC to help in the process of implementing strategy: (1) the possibility to align business and operation strategy, (2) the PPC intention to disseminate the operation strategy on the shop floor and (3) in the company, and (4) disseminate the business strategy in the company. The academic relevance is to extend the usual concept that PPC should be only involved with operation strategy and present the variables that should be focused on by PPC to assist in the process of implementing strategy in sustainable industries. The practical contribution and originality of this research are to present entrepreneurs, executives and leaders that PPC should be used more effectively in an effort to improve the process of strategy implementation, assisting sustainable industries to be more competitive.

1. Introduction

In a world of intense changes, it is important to formulate strategy that can achieve success, but it is also important to implement it, especially in sustainable industries.

Although manufacturing companies are largely responsible for the economic growth of nations, they impact environment and society (Kravchenko et al., 2019; Tiwari et al., 2020; Piyathanavong et al., 2019). Sustainability is based on three dimensions: economy, environment and society that must be interconnected to support a sustainable growth (Elkington, 1999; Hammer, 2015). Sustainable industries are the ones that try to improve their operations to minimize their negative impact (Kumar et al., 2018; Parida et al., 2019; Steger-Jensen et al., 2019), by integrating the economic, environmental and social dimensions of the company (Baas and Hjelm, 2015; Quartey and Wells, 2018).

Sustainable industries need to invest in new processes, technologies, suppliers, research and development to produce in a sustainable process and, at the same time, be competitive in the market, competing against other companies that do not have these concerns or costs, what is challenging (Hughen et al., 2014). For

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this, they need a strategy that can provide competitive advantage (Porter, 1989).

Strategy design and formulation are ideas that need to be put into practice (Contador, 2008; Merkus et al., 2019) through their implementation in the company and, specifically, on the shop floor under the risk of the formulated strategy will no longer be implemented and the company will not achieve its objectives (Bai and Sarkis, 2013).

Much research has been done on strategy design and formulation, but less attention has been paid to how strategy is implemented, despite its importance, as if strategy implementation was something mechanical (Chebat, 1999; Engert and Baumgartner, 2016; Johannsdottir and McInerney, 2018), or if the right conditions were created, strategy would be automatically implemented in the company (Merkus et al., 2019).

Strategy formulation is an essential and challenging task, but executing or implementing the strategy formulated in the whole company can be even more challenging (Cândido and Santos, 2019; Merkus et al., 2019; Shahbazi et al., 2016). Scientific studies treat implementation as a 'black box', something invisible, not explaining or specifying it (Merkus et al., 2019). The implementation process is complex and causes stress not only for the people responsible for the necessary changes, but also for the people who will work under the new conditions (Childe, 2007).

Production planning and control (PPC), also known as Production Planning, Programming and Control (PPCP) (Cardoso et al., 2016), plays a key function, being responsible for planning and control production, lot sizes, managing disturbances and reducing their impact, to keep production running regularly (Cichos and Aurich, 2016; Jeon and Kim, 2016; Prinzhorn et al., 2018).

Because of its power to integrate key areas in an industry, some studies have focused on how PPC has implemented strategy in manufacturing companies. Chen and Li (2013) studied the strategy to integrate PPC to partners for information and communication sharing, concluding that, by its central position, an integrated PPC system brings benefits for operating a network manufacturing system. Buestán et al. (2019) presented a framework to help to design or select an appropriate PPC system to provide the means to implement business strategy through actions on the shop floor. Other authors studied the capacity of PPC to disseminate the operation strategy in the production lines, through the central position of PPC (da Silva et al., 2012; Knollmann et al., 2014; Satyro et al., 2016).

Although the main function of PPC is to maximize the economic dimension in the operational process (Putz et al., 2015), there is much research that emphasize the use of PPC to implement strategy to value the environmental dimension. Tsiliyannis (2020) studied how PPC can be used for efficient manufacturing to reduce waste in remanufacturing, stating that it is necessary to have a reliable forecast of the quality and quantity of returns. Schlegel et al. (2019) used waste optimization as a variable for PPC to manage orders in ultra-flexible factories. Heutmann et al. (2019), Willeke et al. (2018) and Sihn et al. (2018) analyzed how energy-efficient production can be achieved, integrating energy controls in PPC systems. Alvarado et al. (2020), Oluyisola et al. (2020) and Pradhan (2019) studied how PC can cooperate to reduce natural resources consumption. Sun and Li (2018) analyzed strategies that PPC can use to optimize energy saving and reduce carbon emissions in manufacturing processes.

Other studies have focused on the role of PPC to implement strategy of sustainability in the operational process. Steger-Jensen et al. (2019) and Putz et al. (2015) analyzed decision factors that should be considered in PPC systems to reduce environmental and social impacts. Akbar and Irohara (2018), Grosse et al. (2017) and Pradhan (2019), studied the inclusion of social parameters, in addition to the environmental and economic ones, to be considered in PPC strategy.

Theoretical research made simplified assumptions for which many practical issues arise, therefore it is important to identify refinements to PPC theory to allow a better fit between practice and production environment (Hendry et al., 2013).

The theory proposes that a company will be in a better competitive position if PPC supports the business strategy (company) as well as operation strategy (production), and this is usually done by choosing an efficient manufacturing process (Buestán et al., 2019; Olhager and Rudberg, 2002), or through efficient operations management (Drohomeretski et al., 2014; Hendry et al., 2013) that can stand the company's competitive priorities.

The aim of this study is to deepen the theory, by analyzing the reach of PPC in sustainable industries in a broader way, far from choosing the most appropriate manufacturing process, or the most efficient operations management to meet the company's competitive priority, but as an important ally in the strategy implementation process in sustainable industries to assist them to be more competitive. The focus is on identifying the variables that can make PPC this important ally, object of sparse studies, a gap in the literature.

This study is divided into sections, being the introduction the first one. The next section (number two) presents a summary of the existing literature about strategy, sustainable development and sustainability, green and sustainable industries and PPC. Section 3 introduces the method with justification for data collection, validation methods and the tool adopted in the study, the Multiple Correspondence Analysis (MCA). Section 4 shows the analysis of the role of PPC in sustainable industries, investigated in terms of: (1) participation in the business and operation strategy formulation, (2) possible influence that PPC could have on the business and operation strategy implementation, in the whole company and on the shop floor, (3) PPC influence on the alignment between business and operation strategy and (4) conflict management. Section 5 highlights the results, brings the limitations of this study and suggests future studies.

2. Literature review

Using Scopus database at the end of August 2020, with the search strings presented in Table 1 in the tittle, abstract and keyword field, not restricting year of publication or any other variable to search, studies on PPC implementing strategy linking to sustainability are sparse, just four documents were found, being one a conference review.

2.1. Strategy and alignment of strategies

There are many different definitions for strategy, depending on the angle of analysis (Almeida et al., 2015; Mintzberg, 1987; Hamel and Prahalad, 2005). Strategy is about thinking profoundly, organize intelligently and execute an action toward a goal target (Grable, 2015).

According to Mintzberg (1987) strategy can be understood as a plan (procedure), ploy (trick), pattern (model), position (situation) and perspective (view). Hamel and Prahalad (2005) state that strategy is to create a new space in the existing industry, suited to the strengths of the company that no other industry has found before. Porter and Heppelmann (2014) argue that strategy is to position a company to do things, create and capture value and ensure competitive advantage.

2.1.1. Theoretical mark

Contador (2008) states that: (a) **Competitive strategy** is a way

Table 1
Search in Scopus database.

Search string	No. of documents
"Production Planning and Control"	1866
"Production planning and control" AND strategy	193
"Production planning and control" AND sustainability	33
"Production planning and control" AND (implement* OR implant* OR apply OR accomplish) AND strategy	57
"Production planning and control" AND (implement* OR implant* OR apply OR accomplish) AND strategy AND sustainab*	4

of confronting competing companies in gaining buyer's preference; (b) **Business competitive strategy** is the competitive strategy of a company or a business unit for the positioning of a product or the company itself in a market and evidences the external vision of the company (the vision it has in relation to customers, competitors and other external factors); and (c) **Operation competitive strategy** is the internal strategy of the company for its departments or functional areas, approaching the choice of means to be used by the company to achieve competitive advantage; it refers to existing skills or competencies to be acquired and defines the internal actions of the company necessary for the implementation of the competitive strategy of business. The concept of Contador (2008) is to increase the competitiveness of the company by obtaining competitive advantages.

The potential of the operation strategy as a powerful weapon is often overlooked by top executives, which usually do not engage with operation strategy and, therefore, reduces the competitiveness of their manufacturing (Skinner, 1969; Wheelwright and Hayes, 1985; Krause et al., 2014).

This study is based on the theory that business strategy and operation strategy are interrelated, each one affecting and being affected by the other (Skinner, 1969; Wheelwright and Hayes, 1985), so it is important that the operation strategy is aligned to the business strategy to be implemented on the shop floor and, therefore, produce objective results (Contador, 2008; Contador et al., 2020).

This study is also based on the theory that the alignment between operation strategy and business strategy occurs when a process, technology, system and production team is willing to endorse business strategy on the shop floor, which in turn, provides the basis for achieving the main goals and the mission of a company (Ansola et al., 2011; González-Benito, 2011).

Aligning operation strategy to business strategy is not an easy task (Marinho and Cagnin, 2014), especially on the shop floor, when operation managers have to take a significant number of decisions (Chan et al., 2014; Satyro et al., 2016), some conflicting with each other and, by carelessness, strategy implementation can be lost.

In a world of so many changes, pressed by the uncertainty of economy (Fener and Cevik, 2015; Luthra et al., 2019), intense competition (Pun and Ghamat, 2016; Rau et al., 2019), climate change (Dubey et al., 2016; Mohamed Shaffril et al., 2019), reduction and scarcity of natural resources (Hofmann (2019); Oliveira et al., 2018; Wang et al., 2019), changing in the manufacturing environment (Chan et al., 2014), among other various factors of pressure, companies tend to lose focus on their objectives and on how they could reach them (Ansola et al., 2011; Bergadaà and Thiétart, 1997; Chan et al., 2014), impacting strategy implementation.

2.2. Sustainable development and sustainability

The natural resources that manufacturing requires to produce are not endless, their capacity of regeneration to provide ours and the next generations has been overemphasized in the last years and now are cause of concern. Additionally, manufacturing is one of the main users of natural resources and responsible for about 38% of CO2 emissions around the world, the most CO2 emission sector, polluting the planet (Global Report Initiative (GRI), 2011; Garetti and Taisch 2012; Taisch 2012).

Sustainable development is defined through the Brundtland Report as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987, p.43). Grounded on this definition, strategy formulation based on environmental sustainability should support a productive system to supply present and future generations (Hansen and Jones, 1996), also taking into account technical limitations, worldwide poverty and social institutions (Bansal and Desjardine, 2015; Newman, 2006).

Once sustainability can be understood as the capability to develop, examine and preserve adaptive capacity (Holling, 2001), strategy formulation based on environmental sustainability should focus on generating and fostering adaptive capacities, transforming the process of environmental management into a progressive process by nature (Newman, 2006). Strategy based on sustainability should be adaptable to support new ideas and thoughts (Crate, 2006), and although there is much understanding of sustainability (Seuring and Mueller (2008)), many industries foster the triple bottom line concept, coined by Elkington (1999), who states that sustainability is based on three pillars: environmental, social (or socio-cultural) and economic conditions, or people, planet and profit (Hammer, 2015).

Other authors state other pillars, such as business case (economic), societal case (social) and natural case (environmental) (Dyllick and Hockerts, 2002), economic prosperity, healthy people, livability and environmental quality (Hammer, 2015), spirituality as the fourth pillar (Inayatullah, 2005), spirituality, gender equity and ecology (Schwing, 2002), employee well-being, social responsibility, organizational commitment and financial performance (Fry and Slocum (2008)).

2.3. Green and sustainable industries

The United Nations Industrial Development Organization (UNIDO, 2010) brings the concept that green industries are the ones that reduce their environmental footprint, maximizing resource efficiency and cleaner production, adopting the three Rs strategy: Reduce, Recycle, Reuse. UNIDO encourages sustainable production and consumption patterns (Kurnia et al., 2018). The concepts of sustainable development are incorporated into the modern idea of green industries (Tarasova et al., 2014).

Sustainable industries are the ones that consider the impact of their operations and product in the (1) environment (environmental dimension) to reduce consumption of nonrenewable resources and emissions to a minimum, improving resources efficiency; (2) society (social dimension) generating benefits to the society in addition to the concern to generate (3) profits (economic dimension) to continue and improve their activities (Kumar et al., 2018; Parida et al., 2019; Steger-Jensen et al., 2019).

While the term 'green industries' is referred to industries that

are committed to the notion of sustainable development, sustainable industries is refereed to industries that are committed to the triple bottom line (TBL) concept of Elkington.

There are many considerations for sustainable industries (Moldavska, 2016), such as: are the ones that increase the value of raw material, products or components, keeping the accessibility of natural resources and environment of quality for future generations (Skerlos et al., 2008), manufacturing processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities and consumers, and are economically sound (Howard, 2007). Considered for others as a synonym of green manufacturing, sustainable industries are the ones that adopt a production process that uses inputs with reduced environmental effect through gains of production efficiency, reduced amounts of waste and/or pollution created with economy, concerned with the social aspect, and also aiming to improve the corporate image (Lakshmimeera and Palanisamy, 2013; Xu et al., 2016).

Elkington (2018) states that companies in general, and mainly those using TBL, should try to be "the best for the world" than "the best of the world," stopping " all of us overshooting our planetary boundaries" and that TBL should be rethought to emphasize this.

Giannetti et al. (2019) propose the FIVE SEctor SUstainability (5 SEnSU) model, where it is possible to see the relationship between natural environment and humans, giving basis to discuss sustainability of production systems under a more holistic approach, considering: (1) Environment (providing resources and receiving residues), (2) Production unit (central to the model), and (3) Society (providing resources [socio-economic resources], and receiving products).

2.4. Production planning and control (PPC)

Production Planning and Control (PPC) plays a key role in industries, such as coordinating, planning the orders and controlling the many aspects of the manufacturing tasks (Cichos and Aurich, 2016; Jeon and Kim, 2016), which are increasingly complex (Caridi, and Cavalieri 2004; Kubat et al., 2007).

PPC is the intermediate between production and customer, represented by sales, being responsible for reaching the logistical and economic objectives of the industries (Seitz and Nyhuis, 2015; Cichos and Aurich, 2016), interfering in the production system to continue producing to attain schedule, guaranteeing the delivery of products within the stipulated deadlines through an economical and efficient operation production (Grundstein et al., 2017; Putz et al., 2015; Yang et al., 2016), contributing to reach business objectives (Monostori et al., 2010; Phillips and Nikolopoulos, 2019).

2.4.1. Production planning and control and strategy implementation

The literature on Production Planning and Control and strategy implementation is basically descriptive.

Abusalem (2018) studied how reducing the variations in the PPC processes assisted new strategies to increase management practices. For the strategy of improving production planning and control, it was possible to implement lean manufacturing in companies, which reduced waste and increased the quality of the production process (Alfieri et al., 2009; Mascarenhas et al., 2019).

There are studies about the barriers of implementing PPC strategy in customized companies (Huang, 2014), industries (Giacon and De Mesquita, 2011; Hendry et al., 2013; Thürer et al., 2011) and furniture sector (da Silva et al., 2012). There are other studies about the new PPC strategy, such as: to increase flexibility and so implement sustainability paradigms through better operational organization (Putz et al., 2015), to implement strategy to reduce lead time fluctuations (Brito et al., 2018; Knollmann et al., 2014), to improve operations (Schmidt, 1998; Stevenson, 2006; Xu et al., 2003), to reduce stock uncertainties (Brito et al., 2018).

3. Method

As a strategy of research, multiple case study was used, involving five renowned Brazilian industrial companies and an automaker that belongs to the top 10 automakers in Brazil, in a total of six companies.

The aim of multiple case study is to increase external validity (Voss et al., 2002) for the development of a theoretical structure, unlike statistical generalizations, which seek to determine the prevalence or frequency of a given phenomenon (Thakkar et al., 2012; Yin, 2010).

Different from the statistical procedure that seeks for a sample set, within a confidence interval to represent the universe or set, multiple case study is limited from six to ten cases (Yin, 2010). If the multiple cases are contradictory, the initial propositions should be reviewed and tested with another set of cases (Yin, 2010).

In order to select the industrial companies for this research, ETHOS Institute (2020), which congregates companies concerned to manage their business with social responsibility and environmental sustainability in Brazil, was contacted. This institute indicated 13 sustainable industries, but just one agreed to participate in this study.

The Industrial Federation of the State of Sao Paulo (FIESP, 2020), which is the largest Brazilian class entity, representing 131 unions of employers with almost 130,000 industries of various sectors and sizes, indicated other 22 sustainable industries. These sustainable industries expressed the relevance of preserving natural resources and respecting people on their websites and have been certified by ISO 14001. The contact with all of them was made by e-mail and telephone, but only four of these companies agreed to take part in this research.

Finally, it was possible to keep in touch with a top-level manager of an important multinational automaker in Brazil, who agreed to participate only if no strategic or secret information was required and under condition of complete anonymity. Fig. 1 displays the selection process for the multiple case study.

A pre-test of the questionnaire was carried out with a former manager of a metallurgical company with 200 employees, when some adjustments were made. The interviews were conducted in Portuguese language. The answers had to be annotated by hand, as the interviewees did not allow the recording of them, as they considered the information confidential. In order not to lose content, as soon as possible, right after the interviews, the answers were rewritten in full, to be as faithful as possible to the interviews.

The multiple case study was supported by interviews consisted of two phases:

First phase - the interviewees were asked to answer a semi-structured questionnaire, with demographic questions, whose results are presented in Table 2. After that, questions were asked about the role of PPC in these industries and possible contributions to the implementation of strategy, presented in the Appendix.

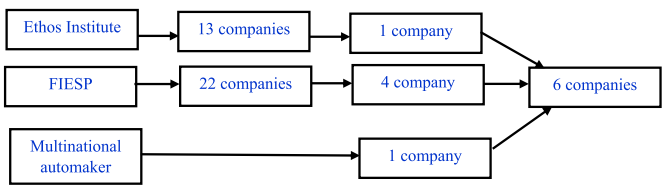

Fig. 1. Selection of the companies for the multiple case study.

Table 2
Industrial companies selected.

Industrial Companies	Sector of activity	No. of Employees	Capital Origin
A	Automaker	More than 9000	Multinational
B	Chemical	400	National
C	Auto parts	700	Multinational
D	Personal & Healthcare	5000	Multinational
E	Auto parts	2000	National
F	Auto parts	160	Multinational

All the respondents were top-level managers, responsible or directly linked to PPC, and the interviews were conducted in their own plants, except the automaker by confidentiality issues, and industry E that was moving its plant and the manager thought it was not convenient to do the interview in the plant for security reasons.

By their hierarchical level, two of the interviewees reported directly to the CEO and the other four to the Industrial Director, or similar position. They had experience in their positions, ranging from 8 to 32-years of experience and all of these companies were continuously operating in Brazil from 20 to 52 years.

Second phase - the interviewees were stimulated to talk freely about any subject that deserved to be mentioned in addition to the questionnaire and also to make any criticism to the questions. The reason was to verify any bias in their answers, comparing the two-phase interview, as stated by Yin (2010) it is necessary to confront evidence to try to improve the trust and reliability of the data collection instrument. No contradiction was found between what was answered in the first phase and what was said in the second phase of the interviews, which could compromise the validation of the data. Fig. 2 presents the research methodology.

The validity of the construct was made through the use of multiple sources of evidences, such as: direct observation, analysis of reports and websites, and public information available in media, were all used to triangulate the evidence to verify the accuracy of the collected data (Yin, 2010). Reliability that is the possibility of replicating the case study, was made by the six multiple case studies carried out, which were used to obtain analytical generalization or external validity (Yin, 2010), discussed in sections 4 and 5 that follow.

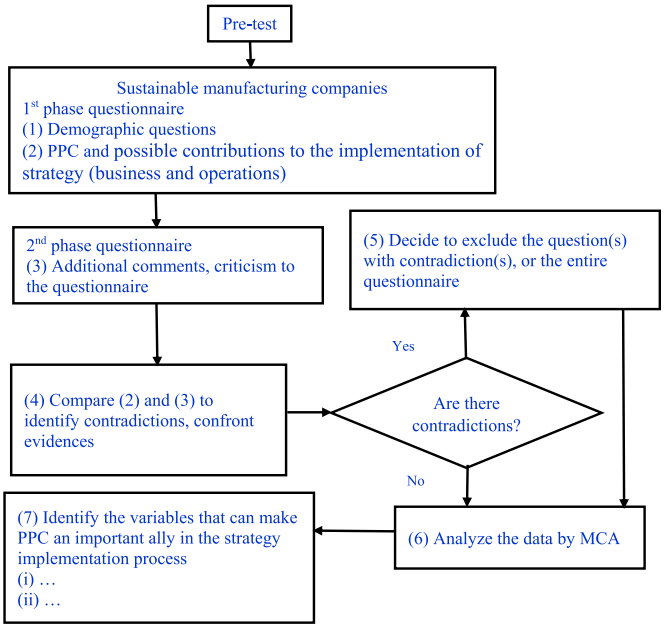

Fig. 2. Research methodology.

This study used Multiple Correspondence Analysis (MCA), which is a multivariate statistical technique that allows the analysis of qualitative data simultaneously. MCA allows studying the relations between three or more nominal variables, reducing the spatial distribution of data to usually two or three dimensions, making it possible to recognize groupings and correspondence between them (Carvalho, 2004; Pestana and Gageiro, 2008). MCA is used for exploratory and descriptive data analysis, transforming qualitative data, associating each one to the scores, allowing not only its graphical representation, but also the separation and proximity of categories (Pestana and Gageiro, 2008).

For each variable, the distance between its categories is reflected in a graph, so that it is possible to analyze the joint graphical representation of a large number of variables and identify similar categories located next to each other; the graphical axles identify the dimensions found in the data (Blasius et al., 2009; Pestana and Gageiro, 2008). The results come from the analysis of visualization of columns and rows of the data table in a usually two-dimensional graphics generated, called map (Blasius and Schmitz, 2015; Blasius et al., 2009; Carvalho, 2004). Due to the standardization used in MCA, the chi-square distance, it can be used to analyze small to large samples (Blasius et al., 2009).

The multivariate statistic of qualitative data was supported by the IBM SPSS v.24 (2016) software to identify homogenous groups among the researched industries (Carvalho, 2004), so that it was possible to analyze the collected answer for each individual group, avoiding possible bias for analyzing all these industries as a whole. The research focus and the categories of classified answers are presented in Table 3.

4. Results and discussion

The IBM SPSS Statistics v.24 software was run reducing to 2 dimensions to provide the map, as presented in Table 4.

Dimension 1 was responsible for 53.9% of the total inertia and dimension 2 for 39.8%, together these two dimensions represented 93.7% of the total inertia. Cronbach alpha was used to evaluate the consistency of the internal scale for each group of statements (Cronbach, 1951). It was possible to select these two dimensions because their Cronbach alpha were more significant or equal to 0.7 considered of good internal consistency (Pestana and Gageiro, 2008; Robinson et al., 1991).

These sustainable industries were compared in dimensions 1 and 2, illustrated in Fig. 3. Industry A and F were isolated from the other industries. Industry A in the second quadrant was an automaker with more than 9000 employees, the biggest in the research, and industry F was an auto part with the lowest number of employees among these industries, 160, also isolated in the third quadrant, so that their analysis were held individually.

Industries B, C, D, and E were closer to each other in the chart, representing greater homogeneity, and although all of them were sustainable industries, they were from different industrial sectors

Table 3
Research focus and categories observed in the answers.

Research Focus	Categories observed
No. of employees	1) Up to 250; 2) 251–500; 3) 501–1000; 4) 1001–5000; 5) 5001 or more
Capital origin	1) National; 2) Multinational
Business strategy formulation (participation)	1) Yes; 2) No
Business strategy (grade of disclosure)	1) Implicit; 2) Explicit
Operation strategy formulation (participation)	1) Yes; 2) No; 3) Partially
Operation strategy (grade of disclosure)	1) Implicit; 2) Explicit
Business strategy (dissemination in the industry)	1) Yes; 2) No; 3) Partially
Business strategy (dissemination on the shop floor)	1) Yes; 2) No; 3) Partially
Operation strategy (dissemination in the industry)	1) Yes; 2) No; 3) Partially
Operation strategy (dissemination on the shop floor)	1) Yes; 2) No; 3) Together with other sectors
Alignment between business and operation strategy (determination)	1) Yes; 2) No; 3) Partially
Management of conflicts	1) Yes; 2) No; 3) Negotiating

Table 4
Model summary.

Dimension	Cronbach's alpha	Variance accounted for		
		Total (eigenvalue)	Inertia	% of variance
1	.922	6.473	.539	53.941
2	.862	4.771	.398	39.759
Total		11.244	.937	
Mean	.897[a]	5.622	.468	46.850

a. Cronbach's alpha average is based on the average eigenvalue.

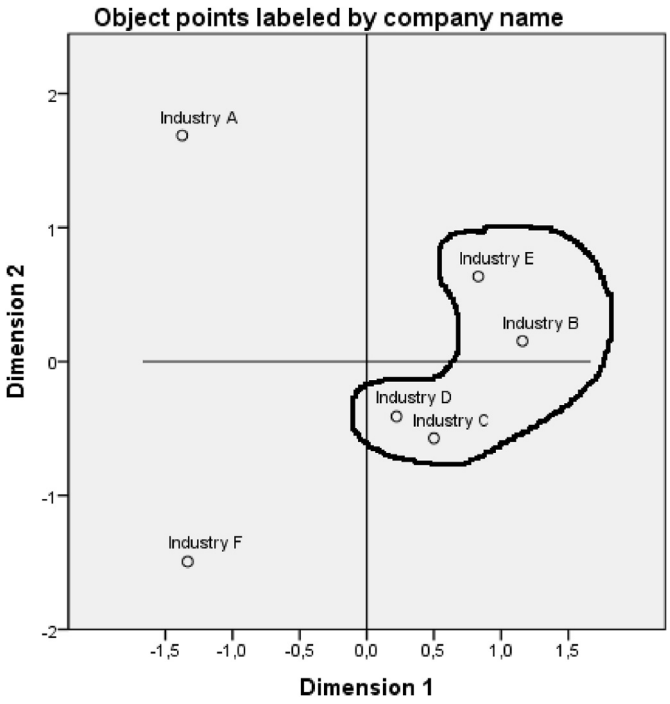

Fig. 3. Reduced dimensions of the selected industries, main variable normalization.

and capital origin (Table 2). Industry B belonged to the chemical sector, national capital, industry D to the personal and healthcare sector, multinational, and industries C and E to the auto parts sector, multinational and national capital, respectively.

Based on Fig. 3, the analysis was divided into three groups: (1) Industry A, (2) Industries B, C, D and E, and (3) Industry F.

The discrimination measures of all variables are presented in Table 5. In gray, the discrimination measures that have values around or bigger than Cronbach's alpha of each dimension were identified (Table 4), showing the most important variables that allow characterizing each dimension.

The 1st. dimension was discriminated essentially by: (1) the number of employees, (2) the purpose of PPC to align business and operation strategy, (3) the intention of PPC to disseminate the operation strategy on the shop floor, and by (4) the business strategy in the company.

The 2nd dimension was mainly discriminated by (1) the number of employees, which discriminated in both dimensions, by the (2) objective that PPC had to disseminate the operation strategy in the company and (3) on the shop floor.

In Fig. 3, the graph of the discrimination measures (Table 5) is presented, where it was possible to identify the variables that better discriminate, considered the ones that were further away from the origin. Those close to the origin are disregarded because they are not distinguished from the normal behavior, that is, the most shared by the respondents.

The interview questions that provided better discrimination are presented in Table 6 and the summary of the answers is shown in Table 7. The total of the questions can be seen in the Appendix.

The number of employees (i) was indicated by MCA as the greater differentiator.

4.1. The variables that can make PPC an ally to implement strategy

The analysis of Table 5 and Fig. 4 lead to the study of the following variables: (i) the number of employees; (ii) the purpose of PPC to align business and operation strategy; (iii) the intention of PPC to disseminate the business strategy in the company, (iv) the intention of PPC to disseminate the operation strategy on the shop floor; and (v) the intention of PPC to disseminate the operation strategy in the company, in three groups: (1) Industry A; (2) Industries B, C, D and E, and (3) F.

The other variables of study presented a lower significance of analysis identified by MCA, so their analysis were discontinued.

MCA helped to discriminate the variables, making it possible to analyze the research on a more consistent basis, which would be difficult using other statistical techniques.

4.1.1. Number of employees

This result suggested that the sector of the industry and capital origin did not differentiate the role of PPC, but the size of the industry represented by the number of employees. The industries B, C, D, and E had from 400 to 5000 employees, industry A had more than 9000 employees, and industry F had 160.

4.1.2. The purpose of PPC to align business and operation strategy

This variable reinforces the understanding of the importance that the operation strategy must be aligned to the business strategy

Table 5
Discrimination measures.

Variables	Abbreviation	Dimension		Average
		1	2	
No. of employees	No. of employees	.969	.909	.939
Capital origin	Capital of origin	.494	.078	.286
PPC participates in the business strategy formulation	PPC participates in bs strgy form.	.688	.005	.347
Grade of bus. strategy disclosure	Grade bus.strgy. disclosure	.087	.533	.310
PPC participates in the operation strategy formulation	PPC particip. oper.strgy (formulation)	.009	.179	.094
Grade of operation strategy disclosure	Grade oper. strgy disclosure	.037	.674	.356
PPC disseminates the business strategy in the company	PPC disseminates bs strgy in co.	.917	.005	.461
PPC disseminates the business strategy on the shop floor	PPC disseminates bs strgy shop fl.	.494	.078	.286
PPC disseminates the operation strategy in the company	PPC disseminates op. strgy in co.	.518	.859	.689
PPC disseminates the operation strategy on the shop floor	PPC disseminates op. strgy shop fl.	.917	.848	.883
PPC tries to align business and operation strategy	PPC tries to align bs and op. strgy	.964	.034	.499
PPC tries to solve conflicts to implement business and operation strategy	PPC tries to solve conflicts to implt bs & op. strgy	.378	.570	.474
Total active		6.473	4.771	5.622
% of variance		53.941	39.759	46.850

Table 6
Interview questions that provided better discrimination.

Questions that provided better discrimination
(i) Number of employees?
(19) Does PPC seek to coordinate so that business strategy (company) and operation strategy (production/operation) are aligned with each other? If so, how?
(13) Does PPC seek to coordinate so that business strategy (company) is taken into account/executed company-wide?
(16) Does PPC seek to coordinate so that the operations strategy (production) is taken into account/executed on the shop floor, or fulfill determinations?
(18) Does PPC seek to coordinate so that the operations strategy (production) is taken into account/executed company-wide, or fulfill determinations?

Table 7
Summary of the answers.

Variables	Group of industries		
	A	B, C, D and E	F
(i) No. of employees	>9000	399 < No.< 5001	160
(ii) PPC tries to align business and operation strategy	No	75% Partially 25% No	No
(iii) PPC disseminates the business strategy in the company	No	100% Partially	No
(iv) PPC disseminates the operation strategy on the shop floor	No	100% Together	Yes
(v) PPC disseminates the operation strategy in the company	No	75% Partially 25% No	Yes

to be implemented on the shop floor, and so produce objective results (Ansola et al., 2011; Contador, 2008; Contador et al., 2020; González-Benito, 2011).

PPC can be used as an ally to provide such alignment, by its key position between the production and the customer, making it possible to connect the internal to the external environment of the industry (Seitz and Nyhuis, 2015; Cichos and Aurich, 2016).

4.1.3. The intention of PPC to disseminate the business strategy in the company

The business strategy must be disseminated in the company, so that all other strategies must be aligned with it to produce positive results (Contador 2008; Satyro et al., 2017; Venkatraman and Camillus, 1984).

It is advantageous to disseminate business strategy throughout the company, which can contribute to assist in its implementation (Benrey (1985); Contador, 2008; Wiig, 1997), and PPC can be included as a key element in this.

4.1.4. The intention of PPC to disseminate the operation strategy on the shop floor

This finding confirms that PPC is a relevant instrument to disseminate the operation strategy in the production lines (da Silva et al., 2012; Knollmann et al., 2014; Satyro et al., 2016), and can be used to implement sustainability paradigms in manufacturing operations (Putz et al., 2015).

4.1.5. The intention of PPC to disseminate the operation strategy in the company

It is relevant that not only business strategy, but also operation strategy, can be known in the company, so the alignment between them can be observed, helping to implement strategy and operation strategy that can be transformed in a powerful weapon, contributing to the competitiveness of the company (Skinner, 1969; Wheelwright and Hayes, 1985; Krause et al., 2014).

The finding of this potential by PPC and the other variables above point to PPC as an important ally in the strategy implementation process (business and operations).

4.2. Industry A

Industry A, with over 9000 employees, reported that its PPC did not play the role of coordinating the alignment of the business strategy (company) and operation strategy (production), nor did it disseminate/implement business strategy within the company, nor disseminate/implement operating strategy on the shop floor or in the company.

The respondent added that PPC had no power over other

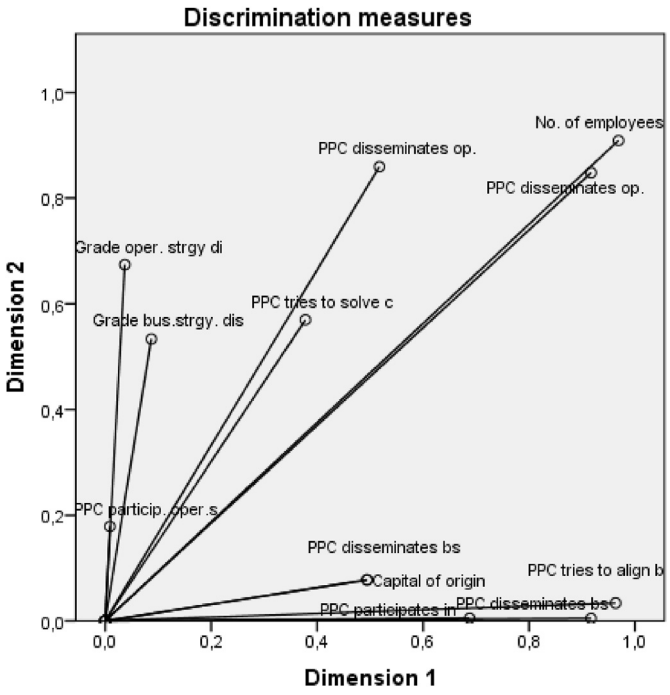

Fig. 4. Graphic representation of the discrimination measures.

departments/areas, was limited to performing its duties, but that PPC was needed as a pathway between sales and production.

Limiting PPC this way, as a restricted department/area confined in its internal functions, industry A did not use the potential of PPC to assist in the implementation of the strategy in the company.

The findings of this study may contribute so that this big automaker can reconsider its position and start to open PPC assignments, so that it can present its potential to assist the implementation of the strategy throughout the company.

4.3. Industries B, C, D, and E

Industries B, C, D and E composed a group with the number of employees varying from 400 to 5000. Three out of four (75%) informed that PPC had partially attempted to coordinate, so that business strategy (company) and operation strategy (production) were aligned, but that PPC was limited in this role because production team also had autonomy to do their job, so they tried to negotiate when necessary and one industry of this group reported that it was not the role of PPC to pursue this alignment.

All these respondents informed that PPC had partially attempted to disseminate/implement business strategy within the company because PPC had a limited role and had no reach over all other departments/areas.

All the respondents also informed that PPC had tried to disseminate/implement the operation strategy on the shop floor, although in conjunction with production/operation personnel, and some others related to it, in a more collaborative way, respecting the limitations of the other departments/areas.

The same majority of this group of industries stated that PPC had partially attempted to disseminate/implement operation strategy within the company due to the limited role of PPC and the necessity of negotiating with other departments/areas. Just one respondent informed that this dissemination/implementation was not the role of PPC.

Being considered an important ally in the strategy implementation process does not imply that PPC will be considered more important than the other departments, or that it can impose itself on others or even just assert their positions, which could cause a power struggle in companies, creating more problems than helping.

PPC is part of the company, so it must work in an integrated way with the other departments/areas, dialoguing and negotiating whenever necessary.

4.4. Industry F

Industry F, with the lower number of employees, mentioned that PPC did not have the direct role of aligning business and operation strategy, being limited at production.

The respondent also informed that PPC interacted with some departments/areas, so PPC was limited to attempt to disseminate/implement business strategy within the company.

The dissemination/implementation of the operation strategy on the shop floor was considered by this respondent as the central role of PPC, involving all departments/areas and hierarchical levels when necessary. The dissemination/implementation of the operation strategy in the company was also considered an essential role of PPC because sometimes PPC had to interact with other areas to provide the continuous production flow.

Restricting PPC to production, industry F did not use the potential of PPC to assist in the implementation of business strategy, which should contribute to increase the competitiveness of the company.

5. Conclusions

The focus of this study is to analyze the variables that can make Production Planning and Control (PPC) an important ally in the strategy implementation process in order to assist sustainable industries to be more competitive. To reach this objective, a research with six renowned Brazilian sustainable industries was conducted, using multiple cases study supported on semi-structured questionnaire and direct observation, when experienced managers were interviewed.

The results indicated that the role of PPC varied accordingly to the size of the industry, here measured by the number of employees. In sustainable industry A, with more than 9000 employees, PPC was limited to its regular routines, remaining restricted, suggesting that the full potential of PPC was not used, and thus reducing operation power to achieve business objectives, in opposition to the orientations of Skinner (1969), Wheelwright and Hayes (1985) and Krause et al. (2014), possibly limiting the implementation of strategy and, therefore, the achievement of the company's objectives.

In sustainable industries B, C, D and E, with the number of employees varying from 400 to 5,000, PPC was more collaborative, tried to negotiate with operation team, was more concerned with trying to implement the operation strategy on the shop floor and in the company, aligning business and operation strategy, promoting strategy for sustainable management, which could improve the strategy implementation process in alignment with the orientation of Hoskisson et al. (2000), Schaap (2006), and Sellitto et al. (2017), and contribute to use the potential of the operation to achieve business objectives, reinforcing the orientation of Skinner (1969), Wheelwright and Hayes (1985) and Krause et al. (2014). In this case PPC is used as an ally to implement strategy. Being collaborative, PPC negotiates and interacts with other departments/areas, without making its opinion/goals prevail.

In sustainable industry F, with 160 employees, the role of PPC varied, focusing on trying to implement the operation strategy on the shop floor and in the company, but without getting involved

with the alignment between operation and business strategy, or with the dissemination of the business strategy in the company, an intermediate position between the two other groups of industries. PPC is limited to operations, and its potential to assist in the strategy implementation is underused.

The academic relevance is to extend the usual concept that PPC should be only involved with operation strategy and present the variables that should be focused on by PPC to assist in the process of implementing strategy in sustainable industries given that, in day-to-day operations on the shop floor, barriers appear and hinder the implementation of strategy (business and operations) in sustainable industries (Chan et al., 2014; Satyro et al., 2016).

The variables identified are: (1) align business and operation strategy, so that process, technology, system and production team can apply business strategy on the shop floor through operation strategy, contributing to reach the company's objectives; disseminate the (2) business strategy and (3) operation strategy in the company, for its key position, involved with many different areas, and being an intermediate between sales and production, PPC should care so that business and operation strategy can be known and aligned in all contacts, conflicts, negotiations, making it possible to maintain the focus on implementing strategy at the most varied levels of the company; (4) disseminate the operation strategy on the shop floor, so that operation can achieve its goals and operation strategy can be a powerful weapon to conduct the company to be more competitive as stated by Skinner (1969), Wheelwright and Hayes (1985) and Krause et al. (2014).

The practical contribution and originality of this research are to provide the ways entrepreneurs, executives and leaders can use PPC as an ally in an effort to improve the process of strategy implementation, assisting sustainable industries to reach their objectives and thus be more competitive.

As a limitation of this research, the results presented could not be generalized due to the reduced number of sustainable industries studied, limited to just one sector of the economy of a developing country, so, for future researches, it is suggested to reproduce the same method in sustainable industries in other countries, with different numbers of employees/other sectors of economy in order to confirm or deny the validity of the findings.

CRediT authorship contribution statement

Walter Cardoso Satyro: Conceptualization, Methodology, Software, Writing - original draft. **Mauro de Mesquita Spinola:** Project administration. **Cecília M.V. B. de Almeida:** Conceptualization, Supervision, Final revision. **Biagio F. Giannetti:** Conceptualization. **José Benedito Sacomano:** Visualization. **José Celso Contador:** Investigation, Visualization. **Jose Luiz Contador:** Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Abusalem, O., 2018. Towards last planner system implementation in gaza strip, Palestine. Int. J. Constr. Manag. 20 (5), 367–384. https://doi.org/10.1080/15623599.2018.1484861.

Akbar, M., Irohara, T., 2018. Scheduling for sustainable manufacturing: a review. J. Clean. Prod. 205, 866–883.

Alfieri, A., Cantamessa, M., Montagna, F., 2009. SoS methodologies for the definition of lean manufacturing systems. IFAC Proc. Vol. (IFAC-PapersOnline) 42 (4 Part 1), 1014–1019.

Almeida, C.M.V.B., Agostinho, F., Giannetti, B.F., Huisingh, D., 2015. Integrating cleaner production into sustainability strategies: an introduction to this special volume. J. Clean. Prod. 96, 1–9.

Alvarado, L., Díaz, J., Quiroz, J., Raymundo, C., 2020. Basic production planning and control model based on process management to increase the productivity of mango MSEs in Casma. Adv. Intell. Syst. 1018, 871–877.

Ansola, P.G., Higuera, A.G., de las Morenas, J., García-Escribano, J., 2011. Decision making platform supported on ICTs: application to the management of ground handling operations at an airport. IFAC P. Ser. 44 (1), 13074–13079.

Baas, L., Hjelm, O., 2015. Support your future today: enhancing sustainable transitions by experimenting at academic conferences. J. Clean. Prod. 98, 1–7.

Bai, C., Sarkis, J., 2013. A grey-based DEMATEL model for evaluating business process management critical success factors. Int. J. Prod. Econ. 146 (1), 281–292.

Bansal, T., Desjardine, M., 2015. Don't confuse sustainability with CSR. Ivey Bus. J. 1–3.

Benrey, Ronald M., 1985. Top-down management communication: the view from mid-channel. IEEE T. Prof. Commun. PC- 28 (3), 17–20.

Bergadaà, M., Thiétart, 1997. Stradin: a strategic dynamic and interactive decision-making process. Group Decis. Negot. 6 (1), 61–75.

Blasius, J., Schmitz, A., 2015. History of correspondence analysis. In: Wright, J.D. (Ed.), International Encyclopedia of the Social & Behavioral Sciences, second ed. Elsevier, Netherlands, pp. 6–11.

Blasius, J., Greenacre, M., Groenen, P.J.F., van de Velden, M., 2009. Special issue on correspondence analysis and related methods. Comput. Stat. Data Anal. 53, 3103–3106.

Brito, T.C., Barreto, B.S., Spaulonci, I., Bergamini, F.P., Longo, A.J., Godinho Filho, M., 2018. Definindo uma estratégia make to availability para uma empresa make to stock de linha branca. [Defining a strategy of make to availability to a white goods Make to Stock company]. Exacta – EP, São Paulo 16 (1), 123–135. https://doi.org/10.5585/ExactaEP.v16n1.7449.

Buestán, M., Van Landeghem, H., López, M., 2019. A framework for the selection or design of production planning and control systems: a case of application. In: Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology 2019-July.

Cândido, C.J.F., Santos, S.P., 2019. Implementation obstacles and strategy implementation failure. Baltic J. Manag. 14 (1), 39–57.

Cardoso, G.T., Puglisi, J.F.S., Seribeli Neto, M., de Sá Filho, P.H., Olivo, A. de M., 2016. Uma abordagem para o estudo do planejamento, programação e controle da produção – (PPCP). [An aproach to the study of the planning, programing and production control – (PPCP)]. Colloquium Exactarum 8, 105–110. https://doi.org/10.5747/ce.2016.v8.nesp.000111. Jul–Dez.

Caridi, M., Cavalieri, S., 2004. Multi-agent systems in production planning and control: an overview. Prod. Plann. Contr. 15 (2), 106–118.

Carvalho, H., 2004. Análise multivariada de dados qualitativos – Utilização da HOMALS com o SPSS, Sílabo, Lisboa.

Chan, F.T.S., Bhagwat, R., Chan, H.K., 2014. The effect of responsiveness of the control-decision system to the performance of FMS. Comput. Ind. Eng. 72, 32–42.

Chebat, J.-C., 1999. Special issue on strategy implementation and assessment research: research on implementation deserves as much attention as strategy formulation. J. Bus. Res. 45 (2), 107–109.

Chen, Z., Li, L., 2013. Information support technologies of integrated production planning and control for OEM driven networked manufacturing: framework, technologies and case. J. Enterprise Inf. Manag. 26 (4), 400–426.

Childe, S.J., 2007. Operations management and people. Prod. Plann. Contr. 18 (8), 627.

Cichos, D., Aurich, J.C., 2016. Support of engineering changes in manufacturing systems by production planning and control methods. Procedia CIRP 41, 165–170.

Contador, J.C., 2008. Campos e Armas da Competição: Novo Modelo de Estratégia [Fields and Weapons of the Competition: New Strategy Model]. Saint Paul, São Paulo.

Contador, J.C., Satyro Cardoso, W., Contador, J.L., Spinola, M.M., 2020. Taxonomy of organizational alignment: implications for data-driven sustainable performance of firms and supply chains. J. Enterp. Inf. Manag. Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/JEIM-02-2020-0046.

Crate, S.A., 2006. Investigating local definitions of sustainability in the Arctic: insights from Post-Soviet Sakha villages. Arctic 59 (3), 294–310.

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. Psychometrika 16 (3), 297–334.

da Silva, E.M., Santos, F.C.A., de Castro, M., 2012. Análise das relações entre estratégia de produção, práticas e desempenho operacional [Analysis of the relations between production strategy, practices and operational performance]. Production 22 (3), 502–516.

Drohomeretski, E., Gouvea Da Costa, S.E., Pinheiro De Lima, E., Garbuio, P.A.D.R., 2014. Lean, six sigma and lean six sigma: an analysis based on operations strategy. Int. J. Prod. Res. 52 (3), 804–824.
Dubey, P.K., Singh, G.S., Abhilash, P.C., 2016. Agriculture in a changing climate. J. Clean. Prod. 113, 1046–1047.
Dyllick, T., Hockerts, K., 2002. Beyond the business case for corporate sustainability. Bus. Strat. Environ. 11, 130–141.
Elkington, J., 1999. Cannibals with Forks: the Triple Bottom Line of the 21st Century Business. Capstone, Oxford.
Elkington, J., 2018. 25 Years ago I coined the phrase "Triple Bottom Line." Here's why it's time to rethink it. online edition Harv. Bus. Rev. https://hbr.org/2018/06/25-years-ago-i-coined-the-phrase-triple-bottom-line-heres-why-im-giving-up-on-it. (Accessed 22 August 2019).
Engert, S., Baumgartner, R.J., 2016. Corporate sustainability strategy – bridging the gap between formulation and implementation. J. Clean. Prod. 113, 822–834.
ETHOS Institute, 2020. O Instituto. http://www3.ethos.org.br/conteudo/sobre-o-instituto/#.WBst6fnQflU. (Accessed 27 August 2020).
Fener, T., Cevik, T., 2015. Leadership in crisis management: separation of leadership and executive concepts. Proc. Econ. Financ. 26, 695–701.
Industrial Federation of the State of Sao Paulo (FIESP), 2020. Sobre a FIESP. http://www.fiesp.com.br/sobre-a-fiesp/. (Accessed 27 August 2020).
Fry, L.W., Slocum Jr., J.W., 2008. Maximizing the triple bottom line through spiritual leadership. Organ. Dynam. 37 (1), 86–96.
Garetti, M., Taisch, M., 2012. Sustainable manufacturing: trends and research challenges. Prod. Plann. Contr. 23 (2–3), 83–104.
Giacon, E., De Mesquita, M.A., 2011. A survey on detailed production scheduling in manufacturing plants in São Paulo, Brazil. Gestão Produção 18 (3), 487–498.
Giannetti, B.F., Sevegnani, F., Almeida, C.M.V.B., Agostinho, F., Moreno García, R.R., Liu, G., 2019. Five sector sustainability model: a proposal for assessing sustainability of production systems. Ecol. Model. 406, 98–108.
Global Report Initiative (Gri), 2011. RG - Sustainability Reporting Guidelines, Version 3.1. http://www.globalreporting.org. (Accessed 21 November 2016).
González-Benito, J., 2011. A theory of purchasing's contribution to business performance. J. Oper. Manag. 25 (4), 901–917.
Grable, C.S., 2015. Why strategy matters. Air Force Comptrol. 48 (1), 5–8.
Grosse, E.H., Calzavara, M., Glock, C.H., Sgarbossa, F., 2017. Incorporating human factors into decision support models for production and logistics: current state of research. IFAC-PapersOnLine 50 (1), 6900–6905.
Grundstein, S., Freitag, M., Scholz-Reiter, B., 2017. A new method for autonomous control of complex job shops – integrating order release, sequencing and capacity control to meet due dates. J. Manuf. Syst. 42, 11–28.
Hamel, G., Prahalad, C.K., 2005. Strategic Intent. (cover story). Harv. Bus. Rev. 83 (7/8), 148–161.
Hammer, J., 2015. When three equals one. Econ. Dev. J. 14 (3), 5–10.
Hansen, J.W., Jones, J.W., 1996. A systems framework for characterizing farm sustainability. Agr. Syst. 51, 185–201.
Hendry, L., Huang, Y., Stevenson, M., 2013. Workload control: successful implementation taking a contingency-based view of production planning and control. Int. J. Oper. Prod. Manag. 33 (1), 69–103.
Heutmann, T., Zhou, B., Schommer, C., Schmitt, R.H., 2019. Integrated energy efficiency in production. IFAC-PapersOnLine 52 (13), 135–140.
Hofmann, F., 2019. Circular business models: business approach as driver or obstructer of sustainability transitions? J. Clean. Prod. 224, 361–374.
Holling, C.S., 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems 4 (5), 390–405.
Hoskisson, R.E., Eden, L., Lau, C.M., Wright, M., 2000. Strategy in emerging economies. Acad. Manag. J. 43 (3), 249–267.
Howard, M., 2007. Sustainable Manufacturing Initiative (SMI): A True Public-Private Dialogue. The U.S. Department of Commerce. https://www.oecd.org/sti/ind/45010349.pdf. (Accessed 25 October 2016).
Huang, Y., 2014. A state-of-the-Art workload control system for customized industry. IEEE Int. Conf. Ind. Eng. and Eng. Manage. 6962602, 1204–1208.
Hughen, L., Lulseged, A., Upton, D.R., 2014. Improving stakeholder value through sustainability and integrated reporting. CPA J. 84 (3), 57–61.
IBM Corp, 2016. IBM SPSS Statistics for Windows, Version 24.0. IBM Corp., Armonk, New York.
Inayatullah, S., 2005. Spirituality as the fourth bottom line? Futures 37, 573–579.
Jeon, S.M., Kim, G., 2016. A survey of simulation modelling techniques in production planning and control (PPC). Prod. Plann. Contr. 27 (5), 360–377.
Johannsdottir, L., McInerney, C., 2018. Developing and using a Five C framework for implementing environmental sustainability strategies: a case study of Nordic insurers. J. Clean. Prod. 183, 1252–1264.
Knollmann, M., Windt, K., Duffie, N., 2014. Evaluation of capacity control and planned lead time control in a control-theoretic model. Procedia CIRP 17, 392–397.
Krause, D., Youngdahl, W., Ramaswamy, K., 2014. Manufacturing – still a missing link? J. Oper. Manag. 32, 399–402.
Kravchenko, M., Pigosso, D.C., McAloone, T.C., 2019. Towards the ex-ante sustainability screening of circular economy initiatives in manufacturing companies: consolidation of leading sustainability-related performance indicators. J. Clean. Prod. 241, 118318.
Kubat, C., Öztemel, E., Taşkın, H., 2007. Decision support systems in production planning and control. Prod. Plann. Contr. 18 (1), 1–2.
Kumar, R., Singh, S.P., Lamba, K., 2018. Sustainable robust layout using Big Data approach: a key towards industry 4.0. J. Clean. Prod. 204, 643–659.
Kurnia, Suryodhahono, B., Dewi, R.I., Saragi, P.A., 2018. The concept of essential facilities in the efficiency of industrial natural resources. E3S Web of Conferences 52, 1–7. https://doi.org/10.1051/e3sconf/20185200022, 00022.
Lakshmimeera, B.L., Palanisamy, C., 2013. A conceptual framework on green supply chain management practices. Ind. Eng. Lett. 3 (10), 42–52.
Luthra, S., Mangla, S.K., Yadav, G., 2019. An analysis of causal relationships among challenges impeding redistributed manufacturing in emerging economies. J. Clean. Prod. 225, 949–962.
Marinho, S.V., Cagnin, C., 2014. The roles of FTA in improving performance measurement systems to enable alignment between business strategy and operations: insights from three practical cases. Futures 59, 50–61.
Mascarenhas, R.F., Pimentel, C., Rosa, M.J., 2019. The way lean starts - a different approach to introduce lean culture and changing process with people's involvement. Procedia Manuf 38, 948–956.
Merkus, S., Willems, T., Veenswijk, M., 2019. Strategy implementation as performative practice: reshaping organization into alignment with strategy. Organ. Manag. J. 16 (3), 140–155.
Mintzberg, H., 1987. The strategy concept I: five Ps for strategy. Calif. Manag. Rev. 30 (1), 11–24.
Mohamed Shaffril, H.A., Samah, A.A., Samsuddin, S.F., Ali, Z., 2019. Mirror-mirror on the wall, what climate change adaptation strategies are practiced by the Asian's fishermen of all? J. Clean. Prod. 232, 104–117.
Moldavska, A., 2016. Model-based sustainability assessment – an enabler for transition to sustainable manufacturing. Procedia CIRP 48, 413–418.
Monostori, L., Erdős, G., Kádár, B., Kis, T., Kovács, A., Pfeiffer, A Váncza J., 2010. Digital enterprise solution for integrated production planning and control. Comput. Ind. 61 (2), 112–126.
Newman, L., 2006. Change, uncertainty, and futures of sustainable development. Futures 38 (5), 633–637.
Olhager, J., Rudberg, M., 2002. Linking manufacturing strategy decisions on process choice with manufacturing planning and control systems. Int. J. Prod. Res. 40 (10), 2335–2351. https://doi.org/10.1080/00207540210131842.
Oliveira, J.H., Giannetti, B.F., Agostinho, F., Almeida, C.M.V.B., 2018. Decision making under the environmental perspective: choosing between traditional and distance teaching courses. J. Clean. Prod. 172, 4303–4313.
Oluyisola, O.E., Sgarbossa, F., Strandhagen, J.O., 2020. Smart production planning and control: concept, use-cases and sustainability implications. Sustainability 12 (9), 3791.
Parida, V., Sjödin, D., Reim, W., 2019. Reviewing literature on digitalization, business model innovation, and sustainable industry: past achievements and future promises. Sustainability-Basel 11 (2), 1–18. https://doi.org/10.3390/su11020391.
Pestana, M.H., Gageiro, J.N., 2008. Análise de Dados para Ciências Sociais: A Complementaridade do SPSS [Data Analysis for Social Sciences: The Complementarity of SPSS, fifth ed. Sílabo, Lisboa.
Phillips, C.J., Nikolopoulos, K., 2019. Forecast quality improvement with Action Research: a success story at PharmaCo. Int. J. Forecast. 35 (1), 129–143.
Piyathanavong, V., Garza-Reyes, J.A., Kumar, V., Maldonado-Guzmán, G., Mangla, S.K., 2019. The adoption of operational environmental sustainability approaches in the Thai manufacturing sector. J. Clean. Prod. 220, 507–528.
Porter, M.E., 1989. Vantagem Competitiva – Criando e Sustentando um Desempenho Superior [Competitive Advantage - Creating and Sustaining Superior Performance], twenty seventh ed. Campus, Sao Paulo.
Porter, M.E., Heppelmann, J.E., 2014. How smart, connected products are transforming competition. Harv. Bus. Rev. 92 (11), 64–88.
Pradhan, B.B., 2019. Production planning and control. Int. J. Psychosoc. Rehabil. 23 (6), 451–456.
Prinzhorn, H., Richter, J., Langner, J., Stonis, M., Nyhuis, P., 2018. Lot sizing in the forging industry considering lot size dependent tool wear. Prod. Eng. 12 (1), 53–63. https://doi.org/10.1007/s11740-017-0777-9.
Pun, H., Ghamat, S., 2016. The value of partnership under competition: when competitors may be R&D joint-venture and supply-chain partners for a critical component. Int. J. Prod. Econ. 177, 1–11.
Putz, M., Stoldt, J., Fanghänel, C., Bierer, A., Schlegel, A., 2015. Making sustainability paradigms a part of PPC. Procedia CIRP 29, 209–214.
Quartey, S.H., Wells, S., 2018. Sustainability-oriented learning: evidence from Eyre Peninsula's fishing industry in Australia. Environ. Dev. Sustain. 1–20. https://doi.org/10.1007/s10668-018-00302-3.
Rau, H., Budiman, S.D., Regencia, R.C., Salas, A.D.P., 2019. A decision model for competitive remanufacturing systems considering technology licensing and product quality strategies. J. Clean. Prod. 239 https://doi.org/10.1016/j.jclepro.2019.118011.
Robinson, J.P., Shaver, P.R., Wrightsman, L.S., 1991. Criteria for scale selection and evaluation. In: Robinson, J.P., Shaver, P.R., Wrightsman, L.S. (Eds.), Measures of Personality and Social Psychological Attitudes. Academic Press, San Diego, CA.
Satyro, W.C., Sacomano, J.B., Contador, J.C., 2016. Production planning and control: the dissemination tool of the operation strategy. IFIP Adv. Inf. Commun. Technol. 488, 844–851. https://doi.org/10.1007/978-3-319-51133-7_99.
Satyro, W., Sacomano, J.B., Contador, J.C., Almeida, C.A., Giannetti, B.F., 2017. Process of strategy formulation for sustainable environmental development: basic model. J. Clean. Prod. 166, 1295–1304.
Schaap, J.I., 2006. Toward strategy implementation success: an empirical study of the role of senior-level leaders in the Nevada gaming industry. UNLV Gaming Res. Rev. J. 10 (2), 13–37.
Schlegel, T., Siegert, J., Bauernhansl, T., 2019. Metrological production control for ultra-flexible factories. Proc. CIRP 81, 1313–1318.

Schmidt, G., 1998. Case-based reasoning for production scheduling. Int. J. Prod. Econ. 56–57, 537–546.
Schwing, R., 2002. A mental model proposed to address sustainability and terrorism issues. Risk Anal. 22 (3), 415–420.
Seitz, K.-F., Nyhuis, P., 2015. Cyber-physical production systems combined with logistic models – a learning factory concept for an improved production planning and control. Procedia CIRP 32, 92–97.
Sellitto, M.A., Luchese, J., Bauer, J.M., Saueressig, G.G., Viegas, C.V., 2017. Ecodesign practices in a furniture industrial cluster of Southern Brazil: from incipient practices to improvement. J. Environ. Assess. Pol. Manag. 19 (1) https://doi.org/10.1142/S1464333217500016.
Seuring, S., Mueller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16 (15), 1699–1710.
Shahbazi, S., Wiktorsson, M., Kurdve, M., Jönsson, C., Bjelkemyr, M., 2016. Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies. J. Clean. Prod. 127, 438–450.
Sihn, W., Sobottka, T., Heinzl, B., Kamhuber, F., 2018. Interdisciplinary multi-criteria optimization using hybrid simulation to pursue energy efficiency through production planning. CIRP Annals 67 (1), 447–450.
Skerlos, S.J., Hayes, K.F., Clarens, A.F., Zhao, F., 2008. Current advances in sustainable metalworking fluids research. Current Advances in Sustainable Metalworking Fluids Research 1 (1/2), 180–208.
Skinner, W., 1969. Manufacturing – missing link in corporate strategy. Harv. Bus. Rev. 47 (3), 136–145.
Steger-Jensen, K., Hvolby, H.-H., Dukovska-Popovska, I., Vestergaard, S., Svensson, C., 2019. Enabling green manufacturing using Advanced Planning and Scheduling (APS) technology. In: 10th IEEE International Conference on Cognitive Infocommunications, CogInfoCom 2019 – Proceedings, pp. 181–186, 9089996.
Stevenson, M., 2006. Refining a Workload Control (WLC) concept: a case study. Int. J. Prod. Res. 44 (4), 767–790.
Sun, P., Li, K., 2018. Methodology – a review of intelligent manufacturing: scope, strategy and simulation. Comm. Com. Inf. Sc. 923, 343–359.
Taisch, M., 2012. Sustainable manufacturing: trends and research challenges. J. Trends Dev. Mach. 16 (1), 1–26.
Tarasova, N.P., Makarova, A.S., Varlamova, S.N., Vavilov, S.Y., 2014. The development of Green Chemistry in Russia as a tool to improve the competitiveness of chemical products [an opinion poll]. J. Clean. Prod. 83, 491–496.
Thakkar, J., Kanda, A., Deshmukh, S.G., 2012. Supply chain issues in Indian manufacturing SMEs: insights from six case studies. J. Manuf. Technol. Manag. 23 (5), 634–664.
Thürer, M., Stevenson, M., Silvaa, C., 2011. Three decades of workload control research: a systematic review of the literature. Int. J. Prod. Res. 49 (23), 6905–6935.
Tiwari, P., Sadeghi, J.K., Eseonu, C., 2020. A sustainable lean production framework with a case implementation: practice-based view theory. J. Clean. Prod. 277, 123078.
Tsiliyannis, C.A., 2020. Prognosis of product take-back for enhanced remanufacturing. J. Remanufacturing 10 (1), 15–42.
United Nations Industrial Development Organization (Unido), 2010. Green Industry for a Low-Carbon Future. A Greener Footprint for Industry: Opportunities and Challenges of Sustainable Industrial Development. UNIDO, Vienna, Austria.
Venkatraman, N., Camillus, J.C., 1984. Exploring the concept of "fit" in strategic management. Acad. Manag. Rev. 9 (3), 513–525.
Voss, C., Tsikriktsis, N., Frohlich, M., 2002. Case research in operations management. Int. J. Oper. Prod. Manag. 22 (2), 195-219.
Wang, J., Du, T., Wang, H., Liang, S., Xu, M., 2019. Identifying critical sectors and supply chain paths for the consumption of domestic resource extraction in China. J. Clean. Prod. 208, 1577–1586.
World Commission on Environment and Development (WCED), 1987. Our Common Future. Oxford University Press, Oxford.
Wheelwright, S.C., Hayes, R.H., 1985. Competing through manufacturing. Harv. Bus. Rev. 63 (1), 99–109.
Wiig, K.M., 1997. Integrating intellectual capital and knowledge management. Long. Range Plan. 30 (3), 399-405+323-324.
Willeke, S., Prinzhorn, H., Stonis, M., Nyhuis, P., 2018. Preconditions for applying an energy price-oriented sequencing rule. Prod. Eng. 12 (1), 73–81.
Xu, H.Q., Besant, C.B., Ristic, M., 2003. System for enhancing supply chain agility through exception handling. Int. J. Prod. Res. 41 (6), 1099–1114.
Xu, W., Shao, L., Yao, B., Zhou, Z., Pham, D.T., 2016. Perception data-driven optimization of manufacturing equipment service scheduling in sustainable manufacturing. J. Manuf. Syst. 41, 86–101.
Yang, S., Arndt, T., Lanza, G., 2016. A flexible simulation support for production planning and control in small and medium enterprises. Procedia CIRP 56, 389–394.
Yin, R., 2010. Estudo de Caso: Planejamento e Métodos [Case Study Research: Design and Methods], fourth ed. Bookman, Porto Alegre.